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HUMAN PROCESSES IN INTELLIGENCE ANALYSIS: PHASE I OVERVIEW

Robert V. Katter
Christine A. Montgomery
John R. Thompson

Operating Systems, Inc.

HUMAN FACTORS TECHNICAL AREA, ARI
OFFICE of DEPUTY CHIEF of STAFF-SYSTEMS, INSCOM

Prepared for

US ARMY RESEARCH INSTITUTE
for the BEHAVIORAL and SOCIAL SCIENCES
5001 Eisenhower Avenue
Alexandria, Virginia 22333

US ARMY INTELLIGENCE
and SECURITY COMMAND
Arlington Hall Station
Arlington, Virginia 22312

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

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JOSEPH ZEIDNER
Technical Director

FRANKLIN A. HART
Colonel, US Army
Commander

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This report provides an overview of the results of a study entitled "Investigation of Methodologies and Techniques for Intelligence Analysis." The goal of this study was to develop a framework for understanding human processes in intelligence analysis. An understanding of these processes will be useful during the development or evaluation of training procedures, doctrine, and system requirements for automated support to analysts.

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The approach taken in this project was a parallel development of intelligence production models and a cognitive model of intelligence analysis. The Imagery Intelligence (IMINT) Production Model ~~(ARI Research Report 1210)~~, developed under this project and an existing Signals Intelligence (SIGINT) production model were used as the basis for developing a generic model of intelligence production, described in this Overview. The generic production model includes a description of the hierarchical flow of intelligence data, tasking, etc., as well as a listing of critical variables influencing analysis. A detailed review of the psychological literature described in ~~ARI Technical Report~~ 445, AD-A086 455 combined with the production models, led to development of a descriptive model of cognitive processes described in this Overview. This overview also explores some of the implications of the cognitive model for training developments, system development, and organizational control of intelligence production. The cognitive model will be extended and these implications will be examined in greater detail during Phase II of this project.

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PHASE I OVERVIEW

Robert V. Katter
Christine A. Montgomery
John R. Thompson
Operating Systems, Inc.

Submitted by:
Edgar M. Johnson, Chief
HUMAN FACTORS TECHNICAL AREA

Approved By:
James D. Baker, Acting Director
ORGANIZATIONS AND SYSTEMS
RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

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FOREWORD

Intelligence collection systems have proliferated over the past several years, increasing in complexity and in volume of output. However, there has been no corresponding improvement in the ability of intelligence personnel to analyze this flood of data. US Army Intelligence and Security Command (INSCOM) studies and Army Research Institute (ARI) research indicate that improved support to and training of analysts are necessary to effectively utilize the increased collection capability and satisfy increasing demands for intelligence within current personnel constraints. INSCOM and ARI therefore initiated a joint research program to provide improved support to the intelligence analyst. During early discussions of the issues, it became clear that any procedural, training, organizational, or system changes to support analysis will be effective only if based upon a detailed understanding of the analysts' role, methods, and thought processes in intelligence production. The first need was to evaluate and describe the human analytic processes underlying intelligence analysis, synthesis, and production. This report provides an overview of the results of this research.

The approach taken in this project was to examine the role and activities of various types of intelligence analysts, and to develop a descriptive model of the cognitive processes involved in analysis. This model derives in large part from current psychological literature and does not provide a new statement of psychological principles. However, these principles are put in a new context, intelligence analysis. This report describes the generalized intelligence production model and the cognitive model. Separate reports describe in detail a model of the production of imagery intelligence (ARI Research Report 1210) ~~and the~~ psychological literature underlying the cognitive model (ARI Technical Report 445).

The research was accomplished by a government-contractor team under contract MDA 903-78-C-2044 and was monitored jointly by INSCOM and ARI. Continuous interaction and collaboration of personnel from Operating Systems, Inc., INSCOM, and ARI insured a multidisciplinary approach to this research.

This report and the others from this project provide a framework for detailed examination of training support and system support requirements in intelligence analysis. These reports should be very useful during the development or evaluation of training procedures or materials, analytic procedures, doctrine, and system requirements for automated support to analysts.

DR. JOSEPH ZEIDNER
Technical Director for ARI and
Chief Psychologist, US Army

MG WILLIAM I. ROLYA
Commander, US Army
Intelligence and Security
Command

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This study was conducted with the assistance and advice of a Study Advisory Group (SAG). The contribution of the individual SAG participants and the cooperation and support of the agencies represented by these individuals greatly benefited the accomplishment of study objectives. In addition to those named below, several INSCOM personnel participanted in the four SAG meetings, several other intelligence activities provided access to analyst personnel, and 117 individuals contributed as much as 6 to 8 hours of their time during interviews and discussions. This high level of participation and support across the intelligence community is gratefully acknowledged.

SAG Participants

G. A. Harvey, Jr.	INSCOM	SAG Chair
E. M. Johnson	ARI	SAG Co-Chair
H. Woodall	ODUSA-OR	
H. W. Taylor	OACSI DA	
C. L. J. Legere	USAISD	
J. E. VanSant	TRADOC	
COL S. T. Weinstein	XVIII Corps	
J. Ribholz	NSA	
A. Heidig	DIA	
LTC C. H. Keller	CACDA	
P. E. Lavigne	INSCOM	
MAJ W. A. Franklin	INSCOM	
CPT M. Hainline	USAICS	
S. M. Halpin	ARI	
R. H. Phelps	ARI	

Human Processes in Intelligence Analysis: Phase I Overview

BRIEF

Requirement:

To develop a framework for describing and understanding the process of intelligence analysis as performed by analysts working with either single-source or multi-source data.

Approach:

A series of structured interviews was conducted with both national and strategic level intelligence personnel experienced in signal, imagery, and all-source intelligence processing and production. Interviews with developers of training materials and observation of classroom instruction and field exercises provided additional information on individual and group responsibilities. Data obtained from interviews and observations were supplemented with documentation and reports based on INSCOM and ARI research. At the same time the research literature on cognitive information processing was reviewed. A descriptive model of the cognitive processes underlying intelligence analysis was developed based on the general principles derived from the literature review and the interviews with intelligence personnel.

Product:

The examination of intelligence analysis identified enviromental and individual variables as well as underlying cognitive processes which contribute to the quality of intelligence. The model describing the cognitive processes of intelligence analysis is expected to serve as a descriptive framework for understanding all levels and disciplines of intelligence analysis. One of the main findings is that intelligence analysis is an internal, concept-driven activity rather than an external, data-driven activity. The present report is an overview of the project, including the cognitive model. A process model of imagery intelligence and a detailed literature review have been published as separate reports.

The findings and descriptive cognitive model could potentially contribute to the improvement of the quality of intelligence products by providing a better understanding of the thinking, analyzing, and memory processes of intelligence personnel. The model can be used to study management and system functions as well as to guide future training and system developments. The results will be incorporated in the development of functional specifications for the All Source Analysis System.

CONTENTS

HUMAN PROCESSES IN INTELLIGENCE ANALYSIS: PHASE I OVERVIEW

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Christine A. Montgomery
John R. Thompson

Operating Systems, Inc.

ABSTRACT

A project was undertaken to construct a general descriptive model of the cognitive activities (mental processes) underlying the activities of intelligence analysis. The approach used to develop the cognitive model combined available information on the way in which intelligence analysis is performed in actual work settings with available research findings in cognitive psychology. The first step was to investigate analytical processing as currently practiced in two types of single-source analysis, and subsequently to generalize to multi-source analysis. The initial interview and observation field study investigated signal intelligence (SIGINT). A second field study investigated imagery intelligence (IMINT) and resulted in a model of the directly observable activities of single-source IMINT production. A questionnaire interview guide was developed and used in deeper study of the two single-source disciplines and multi-source production activities. A concomitant task reviewed literature from cognitive psychology for applicability to the study. A cognitive model was developed, and intelligence analysis activities were studied from the point of view of the model. A main finding is that effective intelligence analysis is a concept-driven activity rather than a data-driven one. Project results have implications for improvements in a number of areas of intelligence work.

1. INTRODUCTION AND OVERVIEW

1.1 Basic Objectives

The study entitled Investigation of Methodologies and Techniques for Intelligence Analysis (IMTIA) has been aimed at constructing a model of the cognitive processes underlying intelligence analysis activities. The present report provides a management overview of the project and its results. Another report [see *Cognitive Processes In Intelligence Analysis: A Descriptive Model and Review of the Literature*] provides an expanded version of Section 8 of the present report, discussing the technical literature basis for the cognitive model in terms of interest to social scientists and technicians. A third report [*Imagery Intelligence (IMINT) Production Model*] was produced by the IMTIA project. Publications used in the project are included in the references.

The IMTIA project aims to improve understanding of the cognitive activities underlying intelligence processing and production. While the intelligence cycle and associated activities are reasonably well-defined and understood, the activities that go on in the head of an intelligence analyst are not. These internal activities have been mainly a 'black box', where only inputs and outputs can be observed and described, and the unobservable processes internal to the black box are unknown. The IMTIA project is directed

at filling this void in the overall understanding of intelligence processing and production. The basic objective of the study was to develop a cognitive model that would provide a framework for the description of the mental processes used in intelligence analysis.

1.2 Overview of Topics

Section 1 summarizes the development approach for the model and outlines the main results and conclusions. Section 2 through 5 are based on interviews and observations in the field. Section 2 describes the organizational structure of the intelligence cycle and treats information flow within that framework. Section 3 presents a generic model for single-source and multi-source intelligence production, describes the core information processing functions of resource management, adaptation, and interpretation, and outlines task processes common to intelligence analysis. Sections 4 and 5 describe environmental and individual variables that affect intelligence analysis activities.

Section 6 presents the cognitive model developed in the course of the study. The model is synthesized from a review of recent cognitive psychology literature. This major section describes the structure of cognitive capacities, the basic dynamic cognitive processes, and the cyclic modification of memory contents. Section 7 describes aspects of analytic work in the light of the cognitive model, and is based on field observations made from the point of view of the cognitive model as it was developed. The final section of the report, Section 8, presents implications of the cognitive model for a number of areas. These include: Improving the accuracy and quality of analytic products; Improving the management of intelligence analysis and the formulation of operating policies and procedures; Providing criteria for the development and evaluation of advanced system designs in support of intelligence analysts; Providing criteria for improving system arrangements for performance feedback; Facilitating efforts to develop and evaluate training programs and training doctrine; and, Providing assistance in personnel selection, motivation, and career planning.

1.3 What is Intelligence Analysis?

The definition of intelligence analysis presented in the *Glossary of Intelligence Terms and Definitions* [see references] reads as follows: "A process in the production step of the intelligence cycle in which intelligence information is subjected to systematic examination in order to identify significant facts and derive conclusions therefrom."

The problem with this definition is that the terms, when used to describe processes inside the "black box", have no frame of reference: What does "systematic" mean? What are the subprocesses in "examination"? What about "identification"? "significant"? "facts"? "derive"? "conclusions"? Although the cognitive model now provides a framework for answering these questions, no such model existed at the outset of this study.

In order to pursue this research, several operating definitions were adopted. A basic definition was that intelligence analysis is what intelligence analysts do -- an understanding of the processes of intelligence analysis and the cognitive processes underlying them must come from the analysts themselves, from observing what they do and asking them about

A subsidiary definition was that the performance of analytical and judgmental activities involving complex cognitive processes is not limited to personnel traditionally called "analysts." Rather -- for the purposes of this study -- intelligence analysis was defined to include a spectrum of analytical and judgmental activities involved in the processing and production of intelligence, where individuals assigned to particular roles in this process may spend more or less time in analytical activity depending on their assigned roles.

For example, signal intelligence (SIGINT) voice intercept operators clearly perform some analytical activity in searching the signal environment; however, much of their duty time is devoted to rather rigidly specified collection activities, involving a minimum of analytical or judgmental processing. On the other hand, image interpreters (IMINT analysts) in a national strategic facility are more continuously involved in analytical activity in searching imagery and must deal with more complex data patterns. In contrast to SIGINT and IMINT specialists, multi-source analysts devote the largest proportion of their time to analytical activity and deal with complex data patterns representing aggregations of single-source data.

1.4 The Core Processes of Intelligence Analysis

Two assumptions about intelligence analysis underlie this research:

1. First, it was assumed that a set of common analytical task processes exists that crosscuts the various intelligence disciplines such as SIGINT, IMINT, and HUMINT (intelligence from human sources). These common analytical task processes support core information processing functions for intelligence analysis.
2. Second, it was assumed that the identification of these common analytical task processes was a key to identifying the core information processing functions of most importance to intelligence analysis. This was viewed as an important step in developing a cognitive model that could provide an especially productive framework for describing intelligence analysis.

1.5 Study Approach

The approach to identifying the set of common analytical task processes and developing a generic cognitive model based on these was first to investigate analytical processing as currently practiced in two types of single-source analysis, and then to generalize the findings to the multi-source analysis environment where possible. As shown in Figure 1-1, the assumptions discussed above and the initial concepts regarding the nature of the analytic task converged to produce the cognitive model described in Section 6. The work represented in the top half of Figure 1-1 was a data-gathering, analysis, and synthesis effort directed at defining the process of intelligence analysis as performed by its practitioners. The work represented in the bottom half of the figure was directed at defining the underlying processes of intelligence analysis in terms of cognitive functions. The cognitive model thus is a blending of the information gathered and generated in answering these two questions.

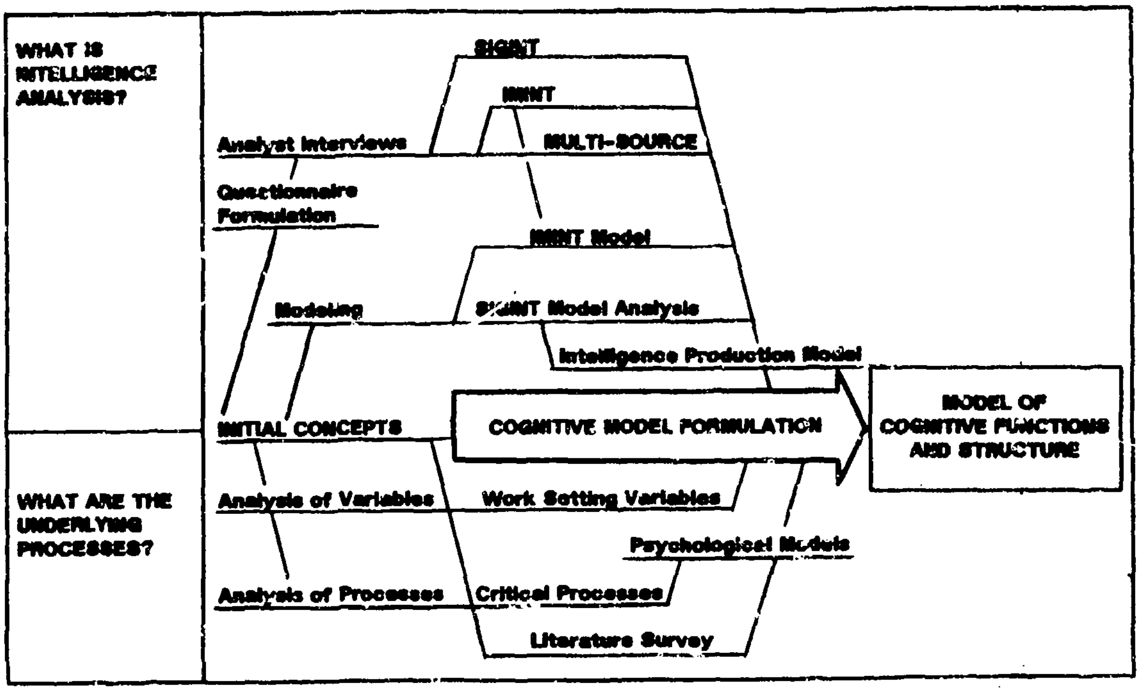

Figure 1-1. The Study Approach

1.5.1 Study of SIGINT Production Model

The initial task involved a preliminary investigation of signal intelligence to identify those SIGINT task processes which appear to have a high analytical and judgmental content. These were selected for further study directed at understanding the underlying cognitive processes. The basis for the initial investigation was the SIGINT production model prepared for INSCOM: [*SIGINT Production Model, Technical Report*].

1.5.2 Development of the IMINT Production Model

The second intelligence discipline investigated was imagery intelligence. Since no comparable production model existed for IMINT, the model described in [*Imagery Intelligence (IMINT) Production Model*] was developed in the course of this study to serve as a basis for selecting IMINT task processes involving high analytical and judgmental content. The selected processes were compared with similar SIGINT task processes in order to provide an initial definition of common analytical task

processes that crosscut the intelligence disciplines.

1.5.3 Preparation of Questionnaire for Detailed Information Collection

The basis for development of the IMINT production model was the intelligence processing behavior of IMINT analysts. In order to systematically collect information on IMINT analysis and to develop more extensive information on SIGINT analysis as well, a detailed questionnaire was prepared for interviewing intelligence personnel in both single-source and multi-source intelligence production activities.

The questionnaire covered the following areas of questions for each interview respondent:

- *Domain Definition* - respondent's client orientation, mission, area of responsibility, input types, information sources, knowledge base, product types.
- *Percepts and Concepts* - respondent's perceptual modes and skills, mental imagery types, difficult/easy tasks.
- *System/Procedural Contexts* - patterns of communication activities, management and quality control arrangements, interpretive aids and references, procedural flexibilities experienced by respondent in work setting.
- *Decision Processes* - respondent's view of work setting situation with regard to conditions for making interpretation decisions, interpretation decision controls, adaptation decision mechanisms used, and prevailing adaptation arrangements.
- *Motivational Aspects* - respondent's views of career path models, personal goals and expectations, goal attainment criteria, relevant skills and knowledge base development.

1.5.4 Site Visits and Analyst Interviews

The questionnaire was used as a basis for conducting the interviews listed in Figure 1-2. Although a number of relevant Army and DoD manuals and reports also provided important basic data for this study (see references), the richest source of information was the community of analysts interviewed and observed as they carried out their work.

Of particular interest are the terms analysts use to refer to themselves and their work. They often see themselves as "detectives," "historians;" their work is like "solving a mystery," a "puzzle," requiring "deduction," "imagination," and "complete concentration." The guiding principle is not only to look and to listen but, more importantly, to think.

These concepts provided insights into the identification of the core analytic functions and the cognitive mechanisms underlying them. The evolving cognitive model was updated and refined in terms of data that indicated significant variables in the analytical environment (described in detail in Section 4.1), in individual training, experience, and knowledge base development (Section 4.2), and in key processes in the analyst's cognition (Section 6).

1.5.5 Selection of Analytical Processing Functions for In-Depth Study

In both the SIGINT and IMINT studies, a set of analytic processes--identified as

MONTH	ORGANIZATION	NO. INTERVIEWS/SPECIALTIES
NOVEMBER	ARMY INTELLIGENCE AND SECURITY COMMAND (INSCOM) NATIONAL SECURITY AGENCEY (NSA)	2/SIGINT 5/SIGINT, 2/IMINT
DECEMBER	INSCOM NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER (NPIC)	3/IMINT 6/IMINT
MARCH	525 MI GP, MIBARS, FT. BRAGG ARMY/AF EXERCISE, SHAW AFB 3428 TECH TRAINING, OFFUTT AFB USAICS, FT. HUACHUCA INSCOM NPIC	10/IMINT 12/IMINT 6/IMINT 13/IMINT, 2/SIGINT 3/IMINT 1/IMINT
APRIL	FT. DEVENS	10/SIGINT
JUNE	BLUE FLAG, EGLIN AFB	6/MULTI-SOURCE
JULY	FORSCOM EXERCISE, FT. A.P. HILL CPAR, FT. MEADE	15/MULTI-SOURCE 9/SIGINT
AUGUST	DETERMINED EAGLE FTX, FT. BLISS	12/MULTI-SOURCE
TOTALS	SIGINT = 28 INTERVIEWS IMINT = 56 INTERVIEWS MULTI-SOURCE = 33 INTERVIEWS	117 INTERVIEWS TO DATE

Figure 1-2. Summary of Sites Visited for Data Gathering

serving functions common across the disciplines of SIGINT, IMINT, HUMINT, and multi-source intelligence-- was selected for further analysis and cross-discipline comparison.

The following criteria were used to select analytic processes incorporating common functions:

- **Analytical orientation** - whether the process is mainly analytical or primarily control and management oriented.
- **Generality** - whether the process appears general to intelligence analysis or specific to the particular discipline of SIGINT or IMINT.
- **Interpretive Complexity** - whether the process involves sparse, possibly conflicting, data that is subject to many potential interpretations, or detailed and unambiguous data whose interpretation is relatively straightforward.
- **Level of Aggregation** - whether the process involves discrete, low-level data patterns or a more abstract level of information that has been aggregated one or more times (for example, SIGINT target detection versus multi-source fusion).

Figure 1-3 shows an initial selection chart for IMINT processes in terms of these criteria (abbreviated to ANAL, GEN, IC, and LOA, respectively). The L, M, and H labels in the figure indicate the evaluation of each process as relatively low, medium, or high with respect to the given criterion. Processes that were evaluated as low in analytical orientation or generality across all three processing phases were not selected. The processes selected are boxed in the figure.

For purposes of comparing SIGINT and IMINT, the following analytic processes common to both were selected:

- Search
- Target Detection
- Target Identification
- Target Development
- Unusualness Analysis
- Functional Analysis
- Complex Studies (e.g., OB Analysis)
- Associated Reporting Processes

1.5.6 Comparison of SIGINT and IMINT Analysis

Using the common task processes selected above as a framework, comparisons were made between SIGINT and IMINT along the following dimensions, which are described in detail in Sections 2 through 5:

- Strategic versus tactical intelligence production.
- Environmental and individual variables:
  - Type of data used.
  - Work setting.
  - Client mission.
  - Training, experience, and knowledge base development and maintenance.
  - Attributes of a good analyst.
- Use of complex conceptual models in analysis.

SIGINT and IMINT are generally perceived as entirely different because of

ANALYTIC ACTIVITY	FIRST PHASE PROCESSING				SECOND PHASE PROCESSING				THIRD PHASE PROCESSING			
	LOA	IC	GEN.	ANAL.	LOA	IC	GEN.	ANAL.	LOA	IC	GEN.	ANAL.
INTERPRETATION												
Search	L	H	L	L	M	H	M	M	H	H	H	H
Target Detection	L	M	H	H	M	M	H	H	H	H	H	H
Target Identification	L	M	H	H	M	M	H	H	H	H	H	H
Target Quantification	L	M	H	H	M	M	H	H	H	H	H	H
Unusualness Analysis	L	M	H	H	M	M	H	H	H	H	H	H
Function Analysis									H	H	H	H
Complex Studies									H	H	H	H
Photogrammetric Sciences									L	L	L	H
REPORTING												
First Phase Reporting	L	M	H	H								
Second Phase Reporting					M	M	H	H				
Third Phase Reporting									H	H	H	H
SUPPORT ACTIVITIES												
Collection Coordination	H	H	H	L	H	H	H	L	H	H	H	L
All Source Data Review & Reduction	H	H	H	H	H	H	H	H	H	H	H	H
History of Coverage Maintenance	L	L	L	H	L	L	L	H	L	L	L	H
Target Development	H	H	H	H	H	H	H	H	H	H	H	H
Interpretation Key Development	H	H	L	H	H	H	L	H	H	H	L	H
Knowledge Base & Skill Development	H	H	L	H	H	H	L	H	H	H	L	H

LOA - Level of Aggregation
IC - Interpretive Complexity
GEN - Generality
ANAL - Analytic Orientation

L Low
M Medium
H High
} Amount of Activity

Figure 1-3. Analytic task processes selected for additional study are enclosed. Any activity scoring low in GEN or ANAL for the three processing phases was eliminated for further study.

the dissimilar modes of data capture and resulting perceptual differences (hearing signals and viewing signal-analysis displays versus viewing terrain-based imagery). In fact, some rather striking parallels emerged from the comparison of SIGINT and IMINT analysis. **The most significant of these was the use of complex conceptual models in analytical work.**

A conceptual model consists of a pattern of generalizations about a given category or range of experience, which depicts a relation or relations between two or more entities, where an *entity* may be an object, an individual, or an event.

For example, IMINT analysts may have a conceptual model of a surface to air missile, in which the model depicts a functional interdependency between a missile and its transporter. If they then see a missile transporter with no missile on it, they may search the surrounding area for places of storage or concealment for the missile. Examples of more

complex conceptual models are the ideas of a communications net, an Order of Battle, a Table of Organization and Equipment, the general relationships between terrain physical characteristics and mobility characteristics, a collection system, etc.

Another important parallel between SIGINT and IMINT analysis emerged from what analysts saw as the key attributes of a good analyst. Both SIGINT and IMINT analysts stated that a good analyst is a "detective", that is, one who discovers what is concealed or tends to elude observation, one who is solving a mystery or a puzzle. The effective analyst must have "imagination" in order to generate good hypotheses about what is happening and what might be concealed, and to do some "detective work" to collect evidence that confirms or refutes these hypotheses. It is important to "be a historian" because one must know what has happened in the past in order to understand what is happening in the present and what is likely to happen in the future.

The major differences between SIGINT and IMINT analysis are attributable to differences in modes of data capture and resulting different perceptual requirements. Several of the SIGINT specialties require a great deal of specific data-capture training (language, morse) in addition to general training in military science (and other areas discussed in Section 5). IMINT analysts on an inactive mission may devote off-duty time and idle time on duty to increasing their general knowledge about the geography and cultural background of the area of mission responsibility, or about types of military equipment likely to appear in imagery generated during exercises. While IMINT analysts are able to spend time in building and maintaining the store of conceptual models that forms the internal knowledge base, SIGINT analysts on an inactive mission are more concerned with not losing language or morse proficiency, rather than with increasing or maintaining general or military knowledge.

Both SIGINT and IMINT analysts find assignments to inactive missions in the tactical environment frustrating because they like their analytical work and know that lack of practice leads to loss of proficiency. The SIGINT analysts have more to lose in such a situation, since data-capture mode knowledge (language, morse), as well as general and military knowledge, will inevitably degrade.

Similarly, although both SIGINT and IMINT analysts prefer analysis to management, SIGINT analysts who moved to management positions where their voice or morse proficiency was not used expressed the most frustration because of the substantial amount of time they had devoted to their early, extensive, career training.

In general, the similarities between SIGINT and IMINT analysis far outweigh the specific differences attributable to different data-capture modes and, consequently, to different modes of perception.

1.5.7 Extension of the Comparison to HUMINT and Multi-Source Analysis

Although a detailed, intensive investigation of HUMINT was not within the scope of the study, some observations of HUMINT analysts at work were made and several discussions were held with IPW (Interrogation of Prisoners of War) analysts. For the most part, it appears that the generalizations about SIGINT

language specialists made in the preceding section also apply to HUMINT analysts. A major difference is the greater importance of special verbal skills for HUMINT analysts, who spend many hours interviewing in a foreign language. Another difference is the relatively greater importance, for HUMINT analysts, of access to multi-source information, which provides them with the necessary knowledge base for helping to elicit information from persons being interviewed.

Extending the comparison to multi-source analysis, the major differences between single-source and multi-source analysis involve:

- higher *levels of aggregation* of the information to be analyzed in multi-source, and to some extent,
- greater *interpretive complexity* for multi-source because of the relatively greater number of conceptual models to be considered.

1.6 Conclusions and Implications for the Cognitive Model

The most telling result of this study is the clear implication that intelligence analysis is conceptually driven as opposed to data driven. What is critical is not just the data collected, but also what is added to those data in interpreting them via conceptual models in the analyst's store of knowledge.

The most important parallel between SIGINT, IMINT, HUMINT, and multi-source analysis involves the use of a large variety of complex conceptual models in analytic activities.

The core functions of intelligence analysis involve the use of complex conceptual models. In turn, the use of such models is dependent upon *individual variables* such as:

- Ability to acquire and comprehend complex conceptual models.
- Ability to generate and evaluate new conceptual models (hypotheses).
- Knowledge, consisting of a general mental inventory of available conceptual models, including mental "index" to locations of models in external memory (in the form of colleagues, files, references, aids, etc.).
- Accurate, reliable memory functioning.
- Special interests and orientations toward conceptual modeling as an activity in its own right, including explicit recognition of models as mental phenomenon, and selective attention and selective memory for certain kinds of conceptual models.
- Mental flexibility and ability to learn from past experience.

The use of such models is also dependent upon *environmental or work setting variables* impacting the analytic process, such as:

- Client orientations (support of tactical versus strategic command, Indications and Warning, mission ops, plans, logistics).
- Production management and tasking (mission, area of interest, product accounting, tasking agencies, work breakdown structure).
- Information acquisition (collection plan, collection gaps, predictability).
- Domain (geographic areas, sociocultural characteristics, terrain features, weather,

economics).

- Data types (sensor types, observers, filtered data, analytical results, expectations).
- Judgmental factors (priorities, time available, communication bandwidth, significance).
- System supports (displays, data bases, colleagues, references, computational aids).

Because both individual and environmental variables affect the analyst's cognitive performance, the model of cognitive processes underlying intelligence analysis must show sensitivity to these variables.

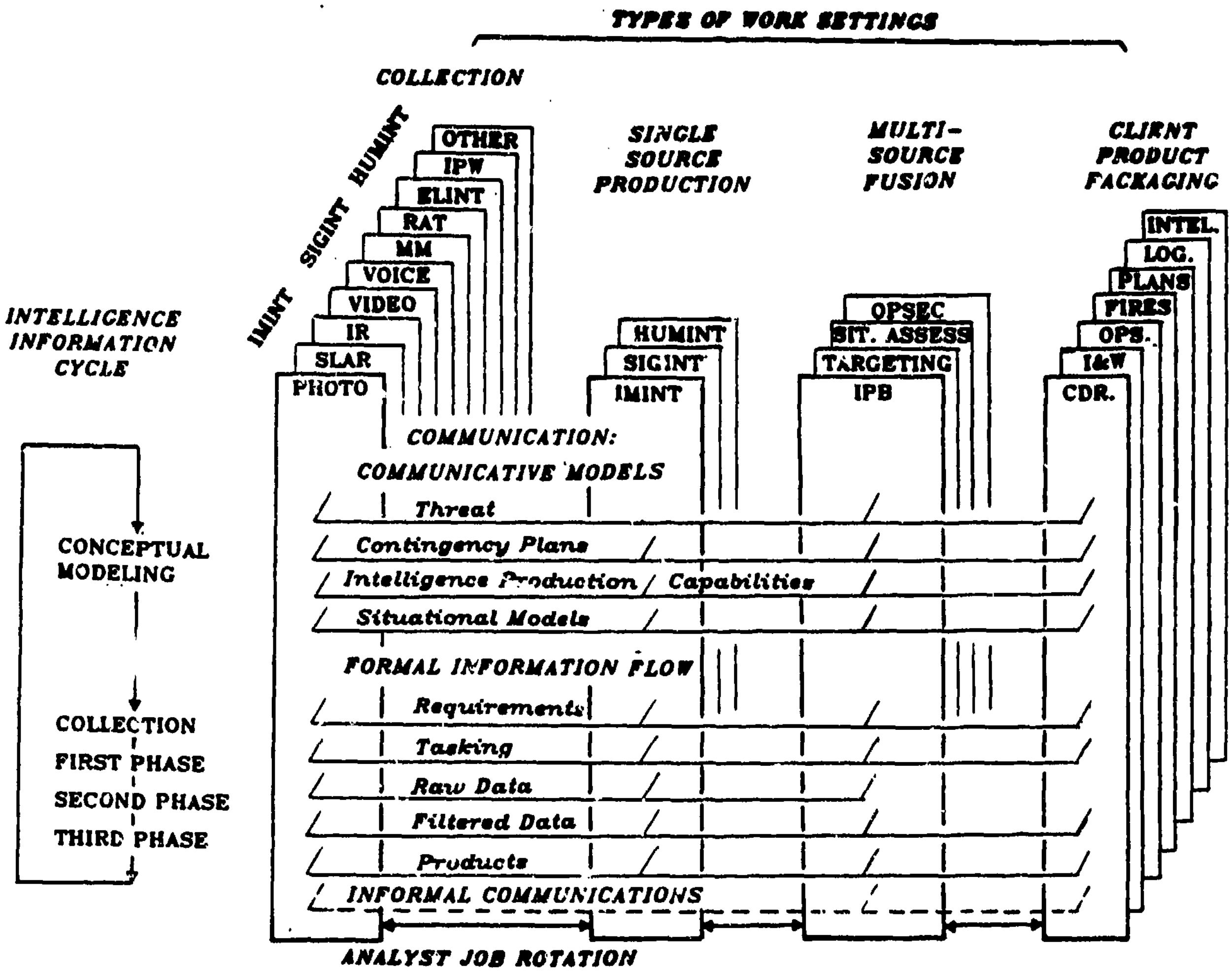

Figure 2-1. Structure of Relations Between Analytic Specialties

2. FRAMEWORK FOR INTELLIGENCE ANALYSIS COMPARISONS

The main dimensions for comparing intelligence analysis specialties are reflected in the work settings in which the specialties are performed. These dimensions include differences in amounts and modes of data to be analyzed, assigned domain from which data are generated, kinds of analytic tasks to be performed on the data, the general range and conceptual level of concerns that are to be brought to bear in considering the data, and the particular context within which the work setting resides. Analysis of the overall organization of intelligence production activities in such terms led to the development of the multi-dimensional structure shown in Figure 2-1, which depicts work settings for various types of SIGINT, IMINT, and HUMINT processing, and their relation to work settings in which higher levels of intelligence data processing are accomplished.

The bulk of Figure 2-1 consists of four interconnected sets of columns depicting the overall intelligence system. At

the left of the figure is shown the intelligence information cycle, which consists of a generalized sequence of four information processing phases that occur throughout the system at most levels and for most modes of data:

- Collection of data that is indicative of capabilities or intentions.
- First phase exploitation of data (high threat and limited response time window).
- Second phase exploitation of data (for current operations and situation assessment).
- Third phase exploitation of data to support basic intelligence needs and special requirements, and review of conceptual models used to interpret data.

2.1 Organizational Structure of Intelligence Analysis Tasks

The main types of settings for intelligence analysis are portrayed across Figure 2-1 from left to right:

- Various modes of intelligence collection (SIGINT, IMINT, HUMINT).
- Single-source correlation and production.
- Multi-source aggregation and fusion (over time and sources) according to mission orientation (IPB, Targeting, Situation Assessment, OPSEC).
- Specific client-oriented information product packaging.

In the figure, main data-flow paths are from left to right, with a corresponding increase in aggregation of data.

2.2 Communication Factors

Besides the main data flows, Figure 2-1 indicates that the various types of work settings are also linked by four kinds of communication factors:

- Communication models.
- Formal information flow arrangements.
- Informal communications.
- Job rotation.

Each of these are considered below.

2.2.1 Communication Models

A communication model is a common conceptual model shared by parties who use it as a means of communication. Such shared conceptual models link intelligence work settings. As defined earlier, a conceptual model consists of a pattern of generalizations about a given category or range of experience, which depicts a relation or relations between two or more entities, where an *entity* may be an object, an individual, or an event. Shared conceptual models are the basis for common understandings of many mutual concerns, including the characteristics of intelligence targets, collection capabilities, use of collection capabilities, and the operating environment. These models are reflected in training plans, in operating doctrine, and in knowledge bases used by analysts.

2.2.2 Formal Information Flow Arrangements

Linking the different special work settings are flows of information through formal communication channels (record and message traffic, mail, command and control communications networks, written orders, etc.). These carry requirements, tasking, raw data, filtered data, and analytical results and products.

2.2.3 *Informal Communications*

Informal communications (via secure telephone, meetings, consultations with peers, interactive digital communications networks, and personal letters) link the work settings, providing analysts with clarifications, feedback, and ready extensions of their own analytical capabilities. A function often served by informal communications is that of making analysts aware of larger perspectives. Interviewed analysts observed that when they were left unaware of the "big picture," they felt isolated and were less able to advance their skills. This condition was cited as being more prevalent in tactical units without an active mission. Analysts in strategic facilities do not exhibit this concern, because of larger local analyst populations and better facilities for sharing information with other organizations.

2.2.4 *Job Rotation*

Job rotation through different work settings serves to link the settings. Analysts report that receiving a variety of tactical and strategic assignments develops a perspective about available information sources (including personal contacts) that are used in analysis. Analysts who have strategic assignments prior to entering the tactical environment know where to obtain tactically useful all-source information.

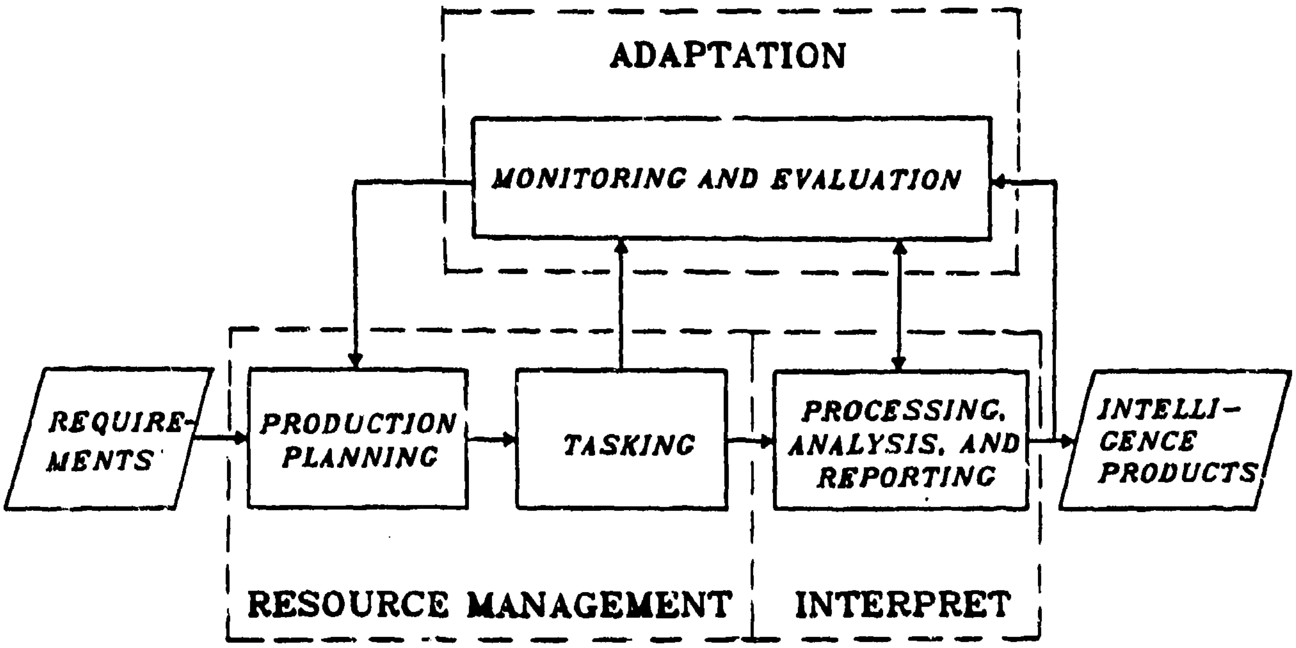

Figure 3-1. Generic Intelligence Production Model

3. GENERIC INTELLIGENCE PRODUCTION MODEL

Analysis and comparison of SIGINT, HUMINT, and multi-source intelligence production led to the development of a model of generic intelligence production processes, shown in Figure 3-1. The model characterizes observable processes common to the three specialities. The processes support three interrelated generic functions performed in analytic work settings:

- Resource Management
- Adaptation
- Interpretation

Interpretation (which encompasses data processing, analysis, and reporting) is the function usually considered as intelligence analysis. However, the resource management and adaptation functions are also included in the present model because of their important effects on the quality of the analytic product and because interpretive decisions are often required for resource management and adaptation.

3.1 Resource Management

The resources allocated to intelligence analysis include:

- Time.
- Analytic personnel capabilities.
- Information flow.
- Information storage capacities.
- Collection assets.
- System facilities.
- Resource management capabilities.
- Adaptive capabilities.

As indicated in Figure 3-1, resource management tasks include planning, allocation, and tasking. Each of these tasks involves decision making by analysts as well as management. Variables considered in resource management decision making include:

- Level of threat.
- Availability of resources.
- Priorities.
- Short term vs. long term benefits.

One of the most important managed resources is time. Mechanisms used to adjust production to time pressures include:

- Segmenting production into phases oriented to product suspense times.
- Controlling the size of geographic area, or number or types of targets handled by one analyst.
- Assigning priorities so that time-sensitive data gets handled first.

In the context of producing specific products, the analyst makes many resource management decisions. Analysts must frequently support multiple missions concurrently and divide their time between several tasks. Analysts may serve several clients when producing analytical results and must make compromise decisions on format and content. The analyst must also find time to secure the long-term benefits of skill maintenance and knowledge-base development. Analysts who were interviewed felt that they had less control over this last category than was necessary to develop and maintain their proficiencies.

3.2 Adaptation

Adaptation is the development of appropriate new responses, by whatever means, in the face of significant change. Figure 3-1 shows the adaptation function as a key feature of the generic intelligence production model. Adaptation of the intelligence production process requires that both the organization and the analysts examine the quality of products and use whatever means are available to correct deficiencies. Adaptation takes place at both individual and organizational levels.

3.2.1 Individual Adaptation

It is impractical to tightly control intelligence production by external monitoring and quality-control checks. The quality of a particular piece of work can be checked only by replicating the entire process, using another analyst with better qualifications, and then making a comparison. This cannot be done on a large scale because of the high cost of the duplicative effort. Thus, the adaptive capabilities of the individual analyst are at a premium. Individual adaptive activities are exemplified by the following behaviors observed during site visits:

- Making voluntary judgments about own performance.
- Seeking informal feedback channels.
- Using non-standard processing strategies (whatever works).
- Using own initiative for increasing awareness in significant areas (information entrepreneurism):
  - Seeking cues from other intelligence sources.
  - Seeking cues from associated elements or processes.
  - Developing contacts in intelligence community or within facility.
  - Developing cultural knowledge to aid in distinguishing cultural background features from significant data.
  - Building continuously the knowledge of "how things work" to aid in interpreting sparse data (e.g., maximum speed and incline capacities of vehicles, weapon ranges, optimum transmitter positioning requirements, etc.)

3.2.2 Administrative Adaptation

Like the individual analyst, the intelligence organization utilizes various adaptive mechanisms when faced with new problems. If a target area that was not being followed in depth suddenly becomes important, the organization may face several adaptation problems:

- Inattention to the area may have resulted in gaps in reference materials.
- Analysts reassigned to the new area will have a substantial start-up time to become familiar with the targets and achieve confidence in interpretations.
- Sociocultural knowledge may not be current for analysts who must work a new geographic area.

The administrative adaptation process is important in the study of intelligence analysis because it contributes factors basic to analytic performance. One of the strengths of strategic intelligence organizations is that they are able to use highly experienced and qualified analysts in the production process. These analysts accumulate a large store of knowledge on specific target areas and are able to perform in-depth interpretations. Sociocultural knowledge at the strategic level can be supplemented by immediate access to State Department and civilian sources.

Because strategic production resources are limited, some target areas must be assigned lower priorities. However, computer data bases maintain archival files of target information stored earlier that can be recovered easily after long periods of lowered attention to particular targets. Such data serve as baselines for renewed closer attention. Communication networks make such data available on a shared basis throughout the strategic community.

On the other hand, intelligence production facilities in tactical echelons below corps are faced with adaptation requirements every time the supported tactical unit must prepare for a contingency operation. The tactical intelligence unit is at a disadvantage in adapting to new contingencies for a number of reasons. Analysts are likely to be less experienced than at the

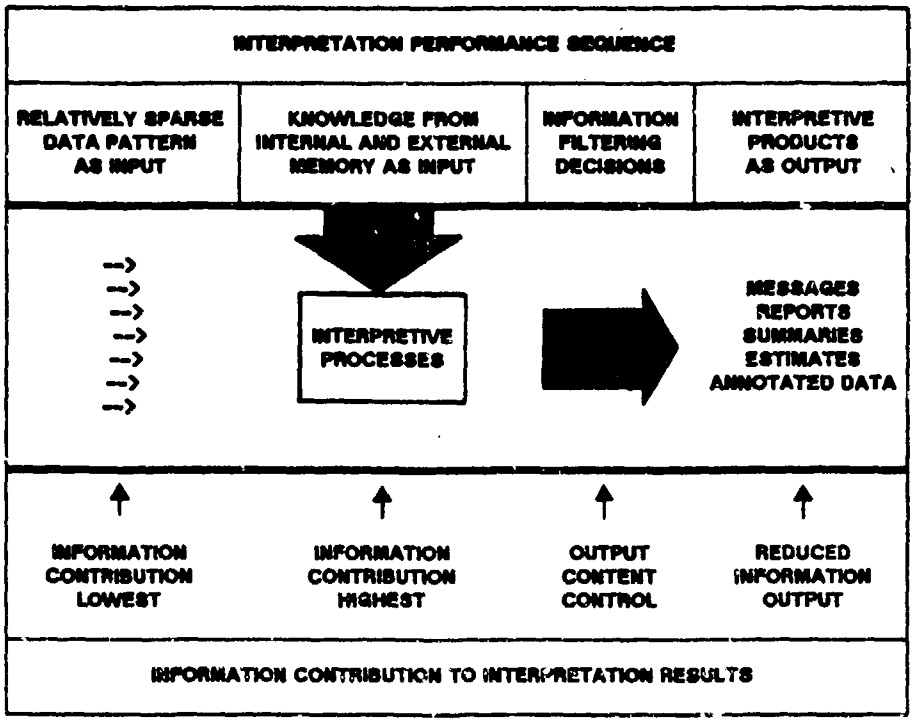

Figure 3-2. Sequence for Intelligence Interpretation Task

strategic level, and highly experienced analysts may be unavailable to assume training roles. Personnel shortages may draw analysts away from analytic training duties. If the unit does not have a current active mission, analysts may not be current on the intelligence threat and may not be garrisoned in a location close to the resources needed to maintain knowledge for areas of likely operation. Storage facilities are often not available for archival data that would be useful in preparing for a wide range of contingencies. Personnel clearances and billets for sensitive compartmented information may be in short supply. Real data may be unavailable for analysts to work with. Interaction with community intelligence resources is sometimes difficult.

In the worst case, the tactical unit must depend almost entirely upon the individual skills and backgrounds of analysts to adapt to new operational requirements.

3.3 Interpretation

Although the generic production model depicts interpretation as only one of three main analytic functions, it is, in fact, the basic one. Figure 3-2 shows the interpretive processes as a cycle

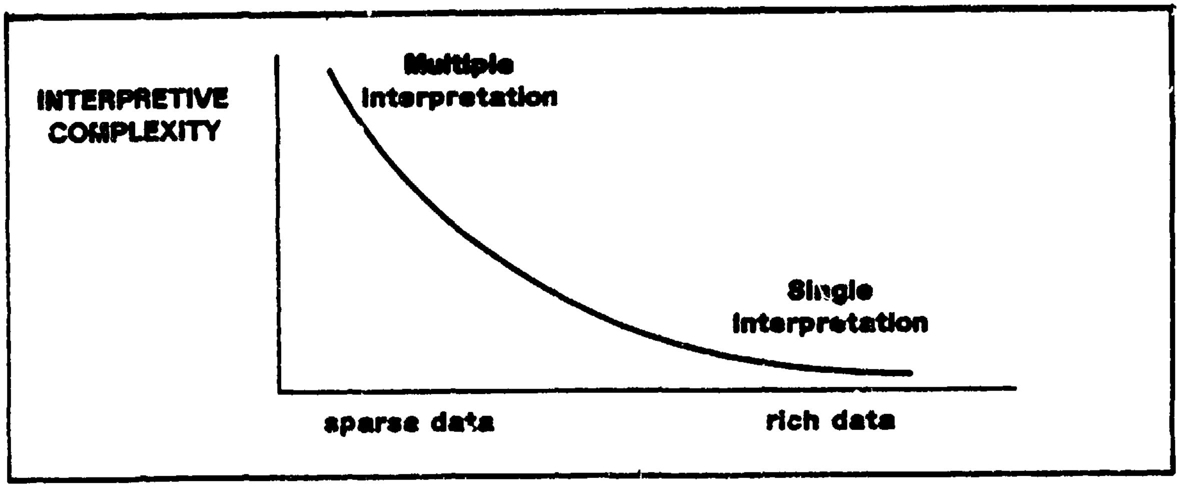

Figure 3-3. Interpretive Complexity as a Function of Data Richness and Number of Supportable Interpretations

of (1) receiving incomplete or sparse data, (2) interpreting the data, and (3) formulating the intelligence product (messages, estimates, etc.). The central function of interpretation involves making many information filtering decisions in the process of converting sparse or uneven input data to intelligence products. The basis for such decisions is usually memory-stored conceptual models of the types of real-world objects or events thought to have generated the data being interpreted.

Figure 3-2 also summarizes our observation that, of the information going into the interpretive product, a greater amount comes from conceptual models stored in memory (both internal and external memory), than from the data being interpreted. In other words, intelligence analysis is usually more a concept-driven than a data-driven process.

3.3.1 Interpretive Complexity

Interpretive complexity is a composite evaluation of the relative difficulty of analytic tasks. Interpretive complexity is inversely proportional to the richness of the input data and directly proportional to the number of reasonable alternatives against which an interpretive decision must be made. Figure 3-3 illustrates this relationship. Thus situations which are the most difficult and complex to interpret are those in which there are few data available but for which many viable interpretations are possible; other situations in which there are many data that point to a single obvious interpretation are low in interpretive complexity.

Another factor in interpretive complexity is the level to which the input data have been aggregated. Data may be

aggregated over periods of time, over multiple sources, or in levels of abstraction (e.g., n artillery pieces vs. a battery). Aggregation of input data can work positively or negatively in the interpretation process. If the aggregation is done properly, the richness of the input data is increased and interpretive complexity is lessened. On the other hand, aggregation can interject biases due to normalization, to incorrect interpretation in abstraction, or to removal of valid ambiguities in preprocessing.

Based on our observations three conclusions about interpretive complexity have been drawn:

- The more complex interpretation tasks are usually performed by more experienced analysts better able to cope with higher levels of data aggregation.
- Interpretive complexity is often greater in work settings using high levels of data aggregation, because analysts must make decisions on the interpretation quality of their inputs as well as make their own aggregation choices and interpretive decisions.
- There is sometimes distrust of interpretations received from work settings at lower levels of aggregation unless the using analyst has trust in the source.

3.3.2 *Knowledge used in Interpretation*

The requirements for the knowledge needed to perform interpretations have their origin in one common definition of intelligence:

Intelligence is the identification of threat; the two components of threat are capabilities and intentions.

The accurate and timely identification of threat requires the use of much sophisticated knowledge organized around conceptual models. Potential threat is inferred at the national level from scenarios (conceptual models) depicting capabilities of:

- Military forces.
- Weapons.
- Strategic industries.
- Economic factors.
- Organization and distribution of power.
- Strategic and tactical disposition of forces and weapons.
- Electronic warfare capabilities.

Inferring intentions to use such capabilities is more difficult. Conceptual models of necessary buildup patterns for threatening behavior are used to infer current and future intentions. The models identify categories of indications and warning signs that are observable through collection assets. Examples of such indicators are:

- Provocative diplomacy.
- Threats/ultimatums.
- Hostile political actions.
- Intimidation.
- Minor military action.
- Major military action.
- Military augmentation.
- Domestic conflict.
- Exercise.
- Peaceful diplomacy.
- Verbal conflict.

In a parallel process, tactical threat is inferred from scenarios depicting capabilities of such things as:

- Positioning and capabilities of individual large weapons.
- Positioning and capabilities of military units of significant size.
- Movements of weapons and units.
- Positioning and movement of logistical units and headquarters.

The best-known threat model is Order of Battle (OB). The OB can be implemented in hardcopy or computer data base form. OB provides capability models of force structures, weapons, status, and disposition. OB also provides insight into intentions of the forces by implication from training, readiness status, tactics, personality of commanders, and strategic or tactical disposition of the forces. OB data is used at all echelon levels, but is tailored to the geographic area of responsibility and to a level of detail that is meaningful to the current situation.

Indicators of threat guide the development of further intelligence information for determining vulnerabilities and planning responses. In planning responses, behavior modeling is used to develop and to authenticate models of possible antagonist reactions. These models predict probable antagonist responses under given sets of circumstances. The importance of behavioral modeling lies in its ability to project "what if?" situations. Because of the predictive nature of these models, they produce speculative, probabilistic results and require continuous refinement and adjustment to maintain their usefulness.

Other types of models frequently used in intelligence analysis are:

- Models of enemy surveillance capabilities and effects of terrain and ECM.
- Political organizations and control of power.
- Command and control organizations.
- Personality profiles.
- Terrain models for use in trafficability or tactical disposition analysis.
- Ethnographic models.
- Chain of events.
- Time and frequency patterns.
- Industrial production models.
- Weapon system performance models.
- Economic models.
- Lines of communications.
- Network models.

These models may be used to transfer general characteristics of known threats to unknown threats by analogy, and to develop higher levels of threat information by piecing together incomplete fragments of data (such as in the Cuban missile crisis, when the existence of Soviet missiles in Cuba was ascertained from the shapes of shipboard containers and from tracks of heavy vehicles around similar shapes seen inland).

3.3.3 *Using Interpretive Models*

The main processes of interpretation involve the extensive use of conceptual models. The skills that enable the analyst to exploit conceptual models include:

- Formulation of conceptual models.
- Storage and retrieval of data using models as the indexing framework (such as situation overlays, OB, installation files).
- Communication with clients by use of models to provide extensive information to supplement the content of messages (such as clients who have local OB files, mission plans, IPB overlays, etc.).
- Correlation of observable real world events with model parameters to deduce capabilities or intentions (such as matching unit maneuvers to the beginning of a mobilization).
- Use of models to inductively determine the threat from unknown elements where analogies exist to known threats (such as extrapolation of Soviet military doctrine to satellite countries).
- Inference of event significance by carrying cause and effect relationships to logical ends (such as impacts of weapon augmentation).
- Fusion of data by abstracting to higher levels of behavior (such as lower echelon units into higher echelon units or individual targets into target clusters).
- Compensation for incomplete intelligence data by fill-in from models (such as using unit identification and location to identify probable locations of associated units).
- Attention to serendipitous events that do not correlate with known models (such as detecting a new weapon system that is distinguished from an old system only in one externally observable characteristic).
- Interpretation of ambiguities by matching to multiple models (such as a unit that could belong to either a motorized rifle regiment or a tank regiment).
- Recognition of uncertainty in interpretations by determining partial matching of events to models (such as being able to locate and identify only 60% of the maneuver units in an observable force whose structural model calls for 40% more).

3.3.4 Filtering of Products

In addition to the conceptual model handling skills, the intelligence analyst must have the important decision-making capability of controlling and filtering data output to the client. In deciding which information should be passed on to the client, the analyst uses at least these three mechanisms:

- Determining change from previous products.
- Understanding the needs of the client and utilizing informal feedback to adjust the content of products or provide clarifications.
- Structuring the output product form such that it is self-defining in terms of its relation to clients' areas of interest and quality of interpretation.

The control of intelligence product dissemination is largely a manual process involving large distribution lists that evolve over an extended period of time. In some work settings, an analyst must designate action and information recipients, select a product form, assign precedence, and select a transmission mode. These decisions

determine the content and speed of delivery of the product.

Intelligence products that are highly formatted and transmitted electrically may be processed directly into client computer data bases. When the client does not have computer assistance, the product flow rate must be controlled by the intelligence production source to prevent saturation of the routing system and the recipients.

3.3.5 Summary of Intelligence Production Model Characteristics

To summarize, the generic model of intelligence production processes identifies three main functional areas: adaptation; resource management; and interpretation. The general types of tasks, such as monitoring and evaluation, production planning, tasking, processing, analysis, reporting, and special product design serve these three main functional areas.

The central function of interpretation involves making many information filtering decisions in the process of converting sparse or uneven input data to intelligence products. The basis for such decisions is usually memory-stored conceptual models of the types of real-world objects or events thought to have generated the data being interpreted.

Comparison of the information constituents of intelligence products with the information constituents of the data supporting the products shows that often a large proportion of the information in the products has been added from memory. Thus, the interpretive process is often more concept-driven than data-driven.

4. ENVIRONMENTAL VARIABLES

Environmental or work setting variables affecting analytic performance are important in the development of the cognitive model because they circumscribe the range of perceptions, decision making considerations, and constraints which the analyst experiences as a result of performing analytic tasks in a given work setting. The scope of environmental variables affecting the cognitive processes of analysts is summarized in the diagram in Figure 4-1.

4.1 Assigned Domain

An assigned domain usually consists of geographic boundaries within which data representing certain target types are to be interpreted. Deep familiarity with geographic, climatic, and sociocultural aspects of the assigned geographic domain is a basic asset to the intelligence analyst. Intimate familiarity with the domain aids in identifying militarily significant targets and in anticipating constraints on military operations. The domain variables depicted as impinging on the analyst in Figure 4-1 become especially obvious during a change of geographic domain. Whenever an analyst is reassigned to a different geographical domain, even though the types of targets may be the same the analyst usually requires a substantial start-up time to regain peak performance levels. The same is true of reassignment of target types within the same geographic boundaries.

4.2 Management and Tasking

Management directives define the domains of an analyst's geographical and functional areas of responsibility in the overall production picture. These tasking constraints change with time. Overlaps in assigned responsibilities are minimized to make efficient use of relatively scarce analytic personnel resources. Nevertheless, requirements for maintaining overlapping knowledge for different areas of responsibility are very common. The intelligence community attempts to develop and exploit such overlap through working groups, information distribution, integrated computer data bases, and informal communications.

4.3 Client Orientations

Figure 4-1 shows client orientations affecting the analyst. Attention to a particular client can improve the value of the analysis product for that client. This goal is sometimes difficult for the analyst to achieve in practice, because many clients are simultaneously served by the production process and the product may thus require an inclusive or compromise format. The importance of one client's needs over another also changes.

Tactical intelligence production units have multiple client orientations both in garrison and in deployment. Tactical intelligence units are typically attached to a tactical unit commander, and thereby assigned main client. At the same time, the tactical intelligence unit also has the general intelligence community as a client. It is important to note that the "perceived" client is more critical than the actual end users of a product; an individual analyst or an intelligence unit may adapt to satisfy some goal, but the intended user is not always the sole beneficiary.

4.4 System Supports

The supports available in the intelligence production facility are important to analytic performance. Computational aids and secure communications are valuable assets. Storage space for

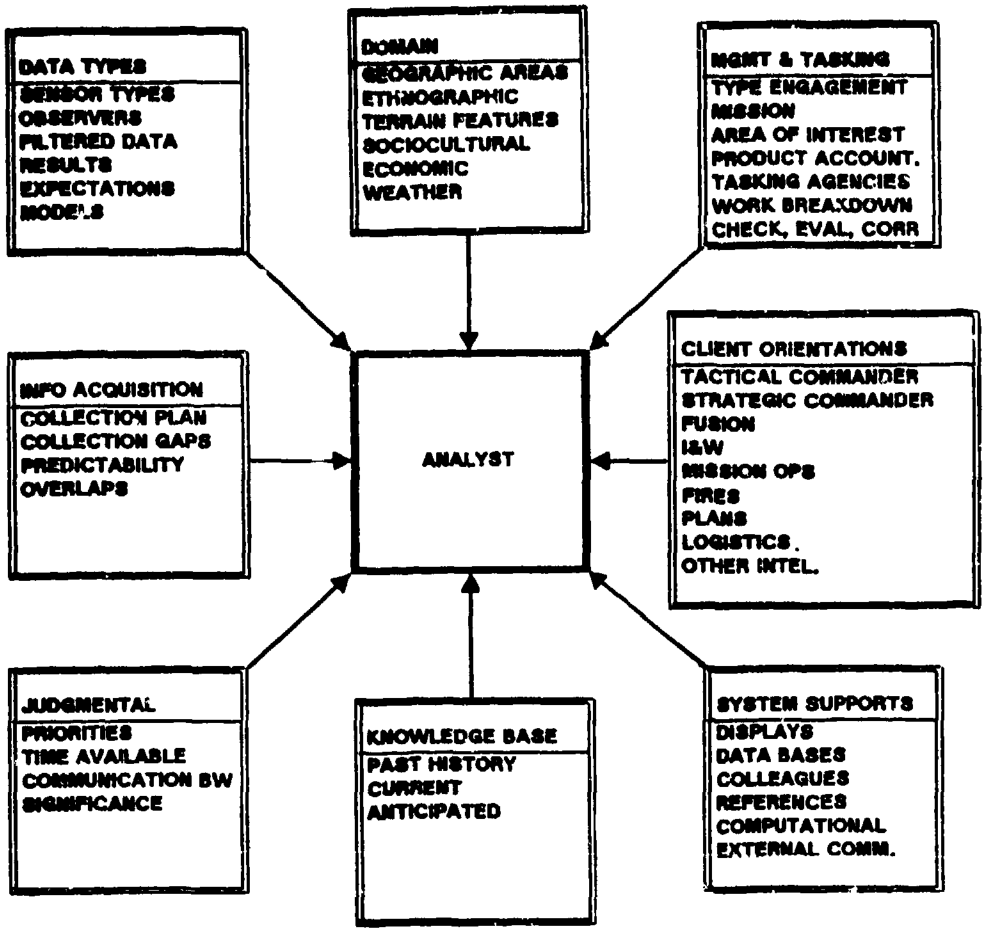

Figure 4-1. Variables in Analytic Work Settings

maps and secure data can make a substantial difference in analytic performance. Film processing facilities are important to IMINT in the same way that electronic signal recording and reprocessing equipment is important to SIGINT.

4.5 Knowledge Base

The knowledge base or external store of information applicable within a given intelligence environment is maintained in the form of materials such as references, archival data files, and computer data base systems. Computer aids are thought to be essential for extending the knowledge base to include archival data that cannot be effectively handled manually.

4.6 Judgmental Criteria

Analysts must exercise judgments on a fairly large number of dimensions. These concern the possible significances of new data for the needs of various analytic clients, the moment-to-moment optimum use of the analytic resources actually available to each analyst, and consideration of the information loads imposed on various analytic clients. Furthermore, these judgmental factors are not static: needs of clients often change rapidly; the load of incoming data to be analyzed changes continuously, the analytic resources actually available to the analyst often change, and the information loads on various analytic clients also varies. As a result of one or more such considerations, the analyst must often modify task priorities and the time allocated to analytic tasks. In a crisis, incoming intelligence data is usually voluminous, and client saturation may occur if the analyst does not actively filter analytic results by significance and client needs. This is particularly important, for example, when the client is a near-real-time intelligence fusion center.

4.7 Information Acquisition

The analyst normally has no direct impact on collection decisions. However, the analyst usually has sufficient knowledge of the collection plan to know what type and how much data will be produced by a mission. For example, in a tactical reconnaissance mission, the original threat analysis may have determined the critical areas for surveillance and projected the types of targets, terrain, and concealment to be found in the area. The analyst may therefore be involved in planning the flight path and briefing the aircrew on air defense threats. Additional information may be gained by debriefing the aircrew after the mission.

4.8 Data Types Familiarity/skills

Many analysts are specialized in one particular data mode. This specialization is formalized by military occupational specialities structured along the lines of data capture modes (voice intercept, manual morse, imagery, etc.). Specialties are also defined for analysts who handle analytical results rather than raw data (cryptanalyst, OB, all-source).

The type of data being analyzed impacts the analytic processes in a number of ways. The related mental imagery differs for various data modes. The information properties (comparative limitations, strengths, "artifactual" contributions) of different data modes reporting the "same" phenomena also vary markedly. The difficulty levels and amount of experience required for acceptable performances vary for different data modes used to report various classes of phenomena. The analyst's "mental world viewpoint" is conditioned by the particular data mode being used.

Very little cross-mode training exists until the analyst moves to a management role. Within imagery interpretation, there are many submodes (IR, SLAR, forward oblique, overhead stereo/mono, video) that an analyst will have proficiency with after a combination of tactical and strategic assignments. Substantial skill-development time is required to adapt to the specific data-capture mode in all specialties, and particularly in SIGINT.

5. ANALYST VARIABLES

A major conclusion from the work performed on this project is that great importance must be placed on the attributes of the analysts tasked with producing intelligence. The main attributes needed are in the areas of:

- Relevant knowledge.
- Skills (perceptual; conceptual; communication).
- Orientation toward managing relevant memory resources.
- Personality.

5.1 Knowledge

The knowledge relevant for analysis includes:

- Military science.
- Science and technology.
- Sociocultural knowledge.
- Sensor mode knowledge.

Background in each of these areas aids the analyst in performing most analytical tasks. Commonalities and differences in knowledge requirements for different analytic specialities are highlighted below.

5.1.1 Military Science

Commonalities between SIGINT, HUMINT, IMINT, and FUSION specialties include an extensive knowledge of military science areas including Order of Battle and military geography. Characteristically, this knowledge is acquired in specific relation to the targets and geographic area within the analyst's assigned area of responsibility. The analyst gradually expands this knowledge base by cross-training or reassignment to other intelligence production facilities.

5.1.2 Science and Technology

Most specialities of intelligence analysis use almost all forms of physical science and technology. A strong technical background helps the analyst understand what is seen or heard in data collected from technically complex targets such as aircraft, missiles, radars, communication nets, factory complexes, and the like. The complex workings of weapons systems, communications, command and control organizations and procedures, and electronics systems must be understood for proper interpretation of intelligence data in both strategic and tactical missions.

Emphatically, this principle holds for all levels of intelligence analysis as defined earlier. Although the inexperienced image interpreter performing a target location or counting function requires much less general knowledge and understanding than an analyst with a more explicit evaluation role, all levels benefit by a thorough understanding in their area of responsibility.

5.1.3 Sociocultural Knowledge

Knowledge of a target country's culture is valuable in discriminating militarily significant items from non-significant ones. Ethnography helps the analyst know where to look for significant items and what to filter out. Sociocultural knowledge is particularly important in strategic intelligence analysis where the use of economic, political, and industrial models may be involved.

5.1.4 Sensor Mode Knowledge

Because the entire intelligence production cycle is included in the scope of intelligence analysis activities, the ability to understand the capabilities of sensor systems is a fundamental knowledge requirement. Although an

imagery interpreter may not need to know how a particular camera works, the constraints under which photographic data is collected must be understood when making decisions about collection plans and the quality of intelligence products.

6.2 Skills

Skills involve knowledge, but are distinguished here from knowledge in terms of added requirements for highly practiced performances.

6.2.1 Perceptual Skills

The phrase perceptual skills, as used here, means practiced performances in discriminating between things on the basis of subtle differences in how they sound or look. Perceptual skills are especially important for single-source intelligence production. There is a strong consensus in the field that the perceptual skills fundamental to SIGINT and IMINT single-source production must be developed by using real data. That is, the refined perceptual skills necessary to interpret particular kinds of images or to recognize certain voices or certain morse or telegraphic operators cannot be fully developed in exercises disassociated from real targets.

The analyst's confidence and speed in interpretation and in the ability to detect significant changes also depend heavily on familiarity with the particular target area. A substantial time period is required to gain such familiarity even for experienced analysts. SIGINT analysts stated that it would take two to six months to adapt to a new target area after being reassigned. IMINT analysts are often semi-permanently assigned by geographic area and/or target types in order to take advantage of the resulting accumulation of perceptual familiarity.

6.2.2 Conceptual Skills

The generic intelligence production model presented earlier depicts intelligence analysis as predominantly concept-driven rather than data-driven. This conclusion was reached after observing the extensive memory resources (see Figure 3-2) that analysts bring to the production of most intelligence products, and noting that much of the memory-based information was conceptual in nature. The production process is also concept-driven in the sense that new intelligence products can be, and often are, produced in the absence of new data. Intelligence preparation of the battlefield (IPB) is an example of an activity that depends almost entirely on previously developed and stored knowledge. As indicted earlier in this report, highly experienced and effective analysts often appear to organize the mental storage of such knowledge around conceptual models. The analyst's ability to deal with conceptual models grows as a result of experience in learning abstract concepts. This type of learning appears to be more in line with that received in higher education than in trade skill learning. Characteristically, analysts who progress to higher skill levels have had post-high school education.

6.2.3 Communication Skills

Foreign language is of special importance to COMINT and HUMINT intelligence production for obvious reasons. From a general standpoint, language skills are vital to the analyst for understanding the meaning of collected intelligence even after it is interpreted. Writing and speaking skills are essential for the analyst to communicate analytic results to clients.

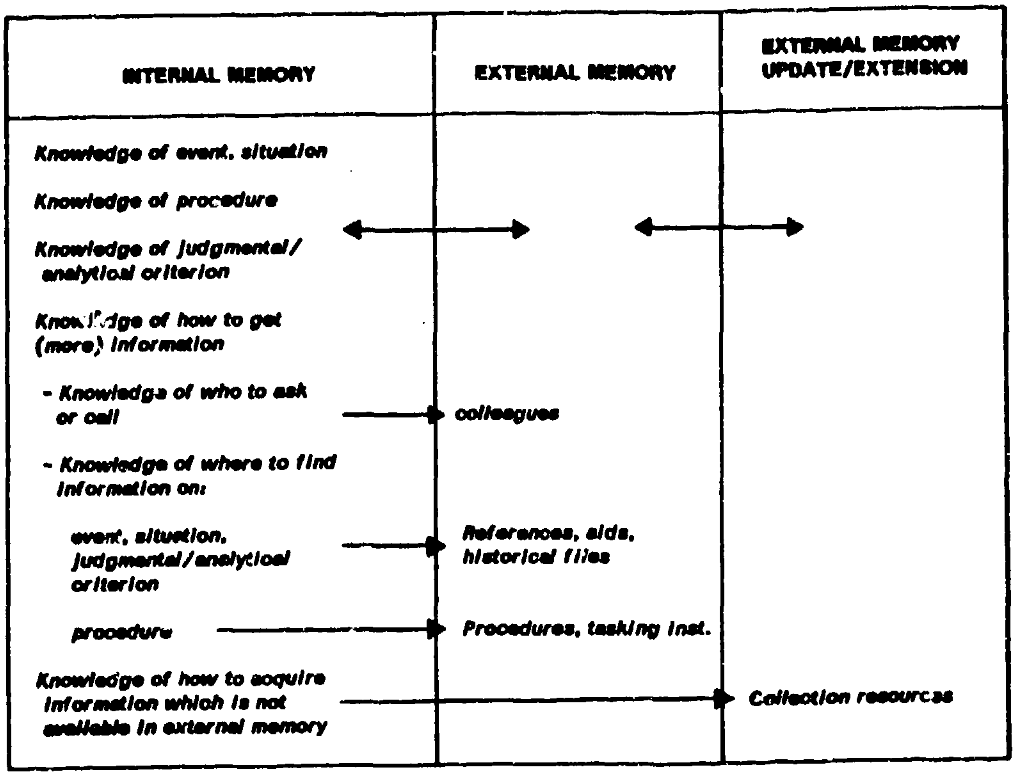

Figure 5-1. The Analyst's Use of Memory Resources

5.3 Memory Management Orientation

The use of information from memory is a centrally important factor in intelligence analysis. This includes not only the use of the analyst's own memory, but also the use of external memory resources available in the extended work setting. The three columns of Figure 5-1, to be discussed in more detail below, depict types of information contents available from internal and external memory, and from the functions for updating/extending external memory. The two-way arrows indicate the reciprocal flows of types of information from storage facilities where they are available to storage facilities where they are not. The one-way arrows indicate the manner in which use of the other two sources of information is dependent upon knowledge contained in internal memory.

5.3.1 Knowledge of Events and Situations

Figure 5-1 shows that the analyst retains an internal memory store of information on situation and current events. An imagery interpreter, for instance, may become so familiar with a

terrain area as to be able to detect any type of change that may be significant. Similarly, a SIGINT analyst may be able to recognize targets on the basis of "personality" characteristics that are not definable in terms of recorded signature information or signal content. An analyst may also review external memory resources, such as situation maps, status displays, and message traffic files, to provide cues that, through mental association, may lead to extending an area of search or expanding the possible interpretations.

5.3.2 *Knowledge of Procedure*

Figure 5 shows that knowledge of procedure resides in internal memory. Other than manuals for operating particular types of equipment or for formatting products, there is almost no documentation on the detailed procedures used in performing analysis. Such procedures are conveyed to the analyst through on-the-job training. The neophyte analyst generally gains proficiency by working closely with experienced analysts who provide assistance and immediate feedback on performance and answer questions on techniques and interpretations. This face-to-face learning relationship is very widespread and recognized as essential in intelligence analysis. It is referred to by some experienced analysts as the "oral tradition" of learning intelligence analysis.

The oral tradition for learning the procedural intricacies of intelligence analysis emphasizes the importance of informal face-to-face communications.

In this regard, it is important that the analyst develop confidence in the ability to analyze and at the same time remain comfortable about asking questions of colleagues when uncertain, since this process continues to be part of many analytic problem-solving situations. The shared group value for "egoless" problem-solving exchanges was frequently observed.

5.3.3 *Knowledge of Accepted Judgmental and Analytical Criteria*

The priorities and significance of analytical results are established through cooperation between the intelligence organization and the client. At the strategic level many of these criteria are long-lived. In tactical environments, the analyst is frequently required to make judgments of changing significances and can therefore profit from frequently renewed contacts with clients, in particular the unit commander.

5.3.4 *Knowledge of How to Get More Information*

The analyst normally works as part of a group of co-located analysts who share the intelligence production workload and operate as a team-memory resource for one another. As indicated by Figure 5-1, colleagues are the most immediate source of knowledge after the internal memory of the analyst is exhausted. In the operation of several intelligence fusion groups during tactical exercises, it was observed that specific areas of memory responsibility were designated to individual members of the analytical team. An analyst assigned a specific content area was responsible for collecting, reviewing, and remembering or maintaining availability of all information pertinent to that area, as well as briefing the fusion team chief when necessary.

Association with experienced analysts is the major source for gaining knowledge of where to find information.

Analysts develop contacts from past assignments or training courses and retain informal communication with those contacts. Mission-defined units of intelligence organizations are not large, and analysts with wide experience are well known in both tactical and strategic settings.

Most analysts supplement personal memory with a "shoebox" of specific references, keys, training material, etc., which are of use in the particular assignment. There is no obvious consistent similarity between the shoeboxes of different analysts.

Computer data bases, such as those of the DIAOLS/COINS network of the Defense Intelligence Agency, are widely accessible in strategic intelligence facilities and are indirectly accessible to tactical units. These computer data bases greatly extend the ability of the analyst to draw on previous analytical work and archival data.

5.3.5 Knowledge of Collection Capabilities

Knowledge of collection capabilities is important to the analyst for two main reasons:

1. To provide judgmental criteria regarding strengths, limitations, and possible artifactual aspects of various collection means, and
2. To provide realistic knowledge about means available for acquiring information unavailable in either internal or external memory.

In most production situations, analysts are isolated from the functions of actually planning collection activities and managing collection resources. However, there is a growing consensus that the generic functions of intelligence production and collection management can be performed more effectively with somewhat closer coordination between the two functions. As a result, it is sometimes found advantageous in the tactical environment for the intelligence analyst to be involved in development of the collection plan at the early stages of deployment, and to provide continuous feedback on the quality of collected data. For example, a SIGINT analyst who understands the limitations of electronic signal detection has a better perspective on the reliability of producing regular intelligence products for the commander. Similarly, the IMINT analyst who understands the problems of the reconnaissance pilot has more accurate expectations of the completeness and accuracy of imagery missions.

5.4 Personality Attributes of the Ideal Analyst

The attributes of the ideal analyst offered by analysts interviewed during the course of this project are summarized as follows. The ideal analyst:

- Is a technologist.
- Is focused (either a specialist or generalist, not both).
- Is an information entrepreneur (as described earlier).
- Is comfortable with changing roles as apprentice, peer, trainer, or consultant.
- Can communicate (written and oral).
- Is a detective.
- Is imaginative.
- Is self-starting/self-organizing.
- Has a profession (intelligence analysis).

- Has related hobbies or technology interests.
- Prefers analysis to management.
- Can perform multiple, concurrent activities.
- Is individualistic.
- Is self-confident.
- Is a historian.
- Has a photographic memory.

This list reflects how analysts feel about themselves. Professionalism is apparent at all skill levels. The most frequent complaint was that tactical unit assignments do not provide an active mission or an adequate access to real data and support facilities to maintain and extend professional skills.

6. THE COGNITIVE MODEL

6.1 Overview

The cognitive model presented here summarizes selected aspects of cognitive functioning that appear to be of central importance to the processes involved in intelligence analysis activities. Each aspect has also been the object of laboratory verification in the field of experimental psychology.

The cognitive model is an abstract description intended to summarize and account for behavioral and psychological observations and their relationships. The model serves to describe interrelated processes that occur inside a person's head when performing intelligence analysis. Cognitive processing is a continuum--some is superficial and some very deep. During superficial processing the individual is sometimes aware of the processing and sometimes not; during deep processing the individual is sometimes aware of the processing and sometimes not. Whether accomplished within or outside awareness, cognitive processing is a dynamic interplay of information from the senses and from internal memory.

The cognitive model presented here focuses on the flow of information through the cognitive "system". describes inputs and processes operating on those inputs to produce outputs. The inputs may come from the external world or from internal memories. The model as presented does not account for all known phenomena or describe all known processes in exhaustive detail. It does provide a framework for understanding cognitive processes in intelligence analysis.

The cognitive model is summarized by the following three points:

1. An individual's initial cognitive processing of information from the environment is conducted within a few tenths of a second by mechanisms operating outside the individual's awareness (termed "automatic" processing.) As depicted in Figure 6-1, information enters through sense organs (eyes, ears, etc.) where it is converted to nerve impulses by automatic (outside awareness) processes and conducted to the brain. There, an automatic process rapidly compares the raw sensory information with information patterns already stored in the individual's memory. This is the COMPARE arrow in Figure 6-1.

   When a gross match is found, parts of the raw sensory pattern are automatically selected because of their similarity to features of the memory pattern and are combined with other elements of the information pattern from memory, shown in Figure 6-1 as the CONSTRUCT arrow. The resulting pattern of combined information, still outside awareness, constitutes the initial version of "meaning" (of a visual scene, of a pattern of sound, of a tactile pattern, etc.) Thus, all initial meanings represent active constructions performed by cognitive processing mechanisms operating outside awareness. As already indicated, such constructions are ordinarily accomplished within a few tenths of a second.

2. Many initial meanings remain outside awareness and trigger patterns of highly practiced adjustments that are also carried on outside awareness. Automatically

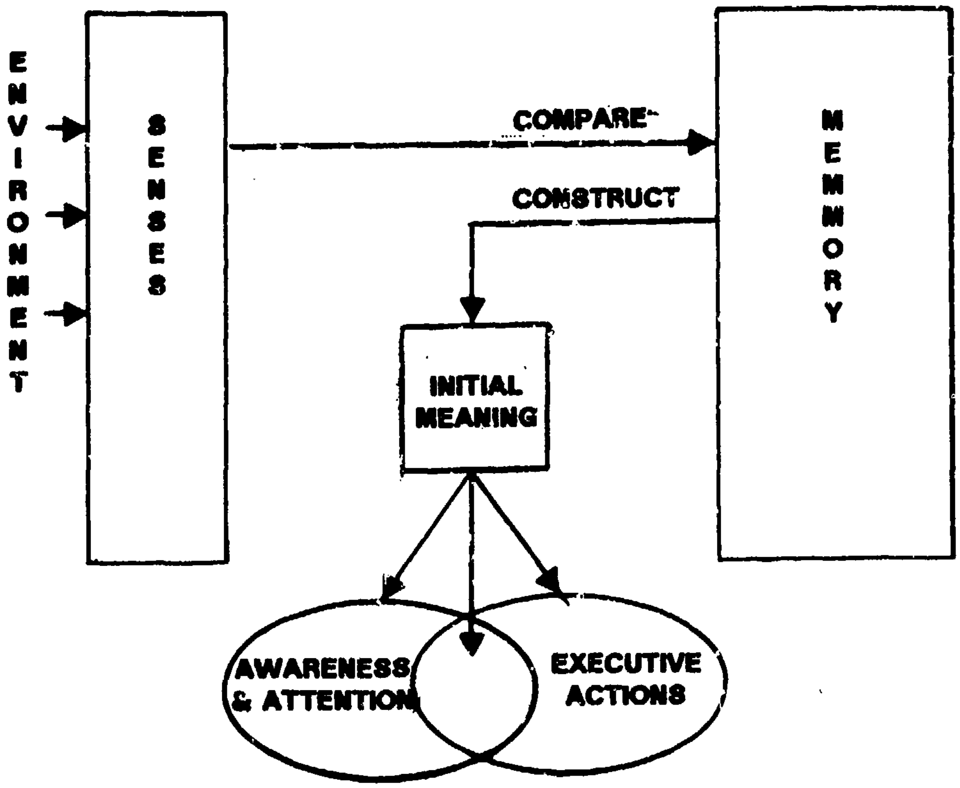

Figure 6-1. Cognitive Model Overview

constructed initial meanings form the bases for generating awareness (when awareness occurs) and for the initial selective focusing of attention on certain aspects of the aware experience. Such responses include automatically ignoring information as irrelevant, uninteresting, or completely expected.

3. The central cognitive function consists of a continuous cycling of the COMPARE/CONSTRUCT process, with each cycle accessing the individual's memory. Each cycle causes some modification of the memory-storage structure of the particular contents accessed. The modification of memory occurs regardless of whether memory information is used only for automatic processing outside awareness or is used also for deeper processing at progressively higher levels of awareness (such as paying close attention, studying a situation, thinking, decision making, and problem solving.)

Three main types of information modification occur as products of the functioning of the basic compare/construct process:

- sensory information filtering,
- memory information consolidation,
- memory access interference.

Analysis of an individual's experiences in terms of these modification mechanisms can provide predictions about cognitive information processing behavior to be expected from that individual. Thus, although individuals have little conscious control over the functioning of their memories and perceptions, the predictable relationships between experience patterns and information modification mechanisms can be used to predict and control the functioning of memory and perception.

The main cognitive functions just described are produced by basic, elemental processing dynamics operating through a structure of underlying cognitive capacities.

To summarize: Human cognition may be characterized as a set of interrelated processes which operate on available information. "Analysis" involves the assignment of meaning to incoming and previously stored information. The descriptive model of analytic behavior developed here builds on an understanding of some of these basic cognitive processes to explain analysts' interpretation, storage, and recall of information. At a very general level the model describes the dynamic interplay between incoming information and previously stored information (i.e., internal memories). Processes which are central to this interplay are the COMPARE/CONSTRUCT sequence and the memory modification cycle involving filtering, consolidation, and access. At a more detailed level the model describes the functioning and implications of these processes and underlying processing dynamics.

In the following paragraphs, memory modification mechanisms are described first, followed by an account of the underlying structure of cognitive capacities and elemental processing dynamics.

6.2 Information Contents Modification Cycle

The COMPARE/CONSTRUCT processing of information depends upon elemental cognitive processing dynamics (to be described later) which operate continuously during wakefulness. The elemental dynamics support three *information modification mechanisms* that operate on the sensory and memory information used by the compare/construct process. Since information from the senses and memory constitutes the raw material upon which intelligence analysis interpretations and estimates are based, the information modification mechanisms have important implications for understanding and predicting the orientations and nature of analytic interpretations and estimates. Figure 6-2 diagrams the information contents modification cycle.

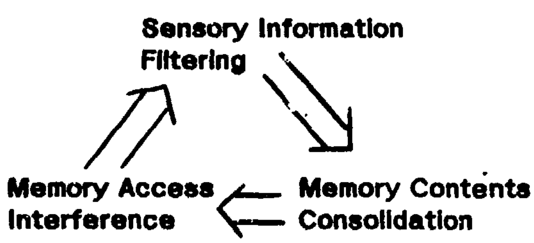

Figure 6-2. Information Contents Modification Cycle.

The cycle is composed of three mechanisms: sensory information filtering, memory contents consolidation, and memory access interference, all of which are described below.

6.2.1 Sensory Information Filtering

The *sensory information filtering* mechanism is composed of two complementary functions: selectivity, and generalization.

6.2.1.1 Selectivity Filtering

Selectivity mechanisms approach filtering from the viewpoint of answering the question: Which aspects of the raw sensory information pattern are significant? The compare/construct process outlined in Section 6.1.1 compares the raw sensory input for similarity with existing memory contents. An adequate gross match is usually found quickly, and the sensory input is relegated to an existing gross mental category.

Thus, the initial compare/construct process often ignores (passively rejects) significant information in the raw sensory input that in fact does not fit (at a deeper, more detailed level of analysis) the mental category assigned to it. If the overall first impression of the sensory information pattern is a good match with gross features of existing memory contents, disparities between the sensory pattern and the memory information pattern at more detailed levels often have no chance to enter awareness.

Polarization filtering is a variation of the selectivity filtering mechanism, in which an expectation that has been established usually increases the accessibility of memory contents related to that expectation (i.e., memory information related to both confirming and denying it). This produces a polarization effect that focuses more attention on the features of the expectation, thus passively rejecting other potentially important information that happens to be irrelevant for confirming or denying the expectation.

The polarization effect can bring positive results when unfolding events correspond to expectations and negative results when events are unrelated to confirming or denying expectations. Polarizing effects are stronger when an expectation is implicit (i.e., is unexamined or unquestioned in awareness). Explicit questioning of expectations can reduce polarization.

6.2.1.2 Generalization Filtering

Generalization mechanisms approach filtering from the viewpoint of answering the question: How much and what kind of similarities are required to recognize things as the same? The confident use of knowledge depends on being able to generalize from experience. Success in applying past experience (memory information) to the present depends on the validity of generalizations employed between the past and the present. The effective use of generalization is a fundamental and inescapable aspect of dealing successfully with the world. The elemental processing dynamics and basic capacities of the cognitive model (to be described later) provide the bases for identifying three main types of mechanisms for filtering by generalization: tolerance, analogy, and fill-in.

6.2.1.2.1 Tolerance Generalization

In *tolerance* generalization, a slot in a memory storage frame (see discussion accompanying Figure 6-5) is filled with new raw sensory information matching that slot. Generalization can occur depending upon the tolerance matching criteria of that slot. Since memory slots

are organized hierarchically by increasing levels of detail of information stored there, tolerance requirements for matching grow more stringent at the deeper, more detailed levels of a memory slot. Of course generalization may be valid or invalid at any level, but looser tolerances increase the chance that raw sensory information is inappropriately generalized.

The mechanism of tolerance generalization usually operates outside awareness. Deeper, more thorough cognitive processing that involves more time spent in highly focused aware comparison between sensory information and memory information can prevent some of the errors introduced by the tolerance type of generalization.

6.2.1.2.2 Analogy Generalization

In *analogy* generalization, comparisons of similarity are made between the patterns of *relationships* connecting the slots of different memory contents storage frames. For example, the memory information about very different social organizations can be compared in order to generate analogies between organizational hierarchy structures; or memory contents depicting the relations between pressure, flow volume, and pipe diameter for water can generate analogies to memory contents for the relations between voltage, amperage, and c· luctance for electricity. The utili· of generalization by analogy depends partly upon the actual relational equivalences bet·een the real-world referents for the analogy, and partly upon the validity of the inferences drawn on the basis of assumed relational equivalences. The mechanism of analogy generalization often operates outside awareness.

6.2.1.2.3 Fill-in Generalization

In *fill-in* generalization, missing parts of the raw sensory pattern are filled in from similar chunks of information in the memory frame slot. If the *reasons* for missing parts of a sensory information pattern are implicitly understood, (either because they are obvious or because of insufficient consideration of the fact of missing information), the fill-in is often automatic. The results of fill-in are advantageous if sufficiently correct and disadvantageous if based on faulty assumptions. Careful examination of assumptions about missing data can raise the level of awareness used in fill-in processing.

6.2.2 Memory Contents Consolidation

Memory contents, including information recently passed through the filtering process and stored, are *consolidated* (i.e., made more accessible and vivid) as a joint function of the frequency of processing and the amount of attention used in the processing. Thus, more frequently encountered, important types of experiences upon which significant mental effort are expended be·come more vivid and immediately accessible in memory.

The increased accessibility and vividness of particular memory contents increases the likelihood that they will be used as filtering criteria in comparing/constructing future, somewhat similar raw experiences (versus using equally appropriate or more appropriate memory contents that are less accessible and less vivid). For this reason the contents consolidation mechanism can have important implications for the accuracy of analytic interpretations and estimates.

If the results of the consolidation mechanism match the realities of future

events to be interpreted, the effects of consolidation are advantageous; if not, the effects are a disadvantage. Long term static conditions tend to increase the favorability of results from the consolidation process, while eras of rapid and significant change do not.

The caricature effect is a type of distortion that can result from the process of consolidation. Mental rehearsal of an experience, rumination about an experience, and problem-solving thinking about an experience can increase the accessibility and the vividness of the particular memory contents related to that experience. Given no additional external information about a certain experience, continued rehearsal, rumination, and thought tends to emphasize and deemphasize various aspects of the memory of that experience.

The result of emphasis and deemphasis is to "normalize" usual or expected aspects of the memory and to exaggerate unusual or unexpected aspects, with usualness/unusualness being judged in relation to the rest of the overall memory structure. That is, the consistency or usualness between some of the contents of the particular memory and the balance of memory contents may be exaggerated beyond their original consistency, and the disagreement and inconsistency in other parts of that particular memory may also be exaggerated beyond their original condition.

Since the combined results of these processes tend to produce a memory that is a caricature of the original contents, the result has been termed the *caricature effect*. This effect tends to feed on the elements of unusualness and surprise and to overweigh these elements as compared to the more expected elements of experience. If the situation is such that novel elements of an experience are accurate portents of a future similar event, the caricature effect may provide help in interpretation when it arrives. If not, the caricature effect can be an impediment to accurate interpretation, especially if the interpretation must be based on incomplete data.

The caricature effect is a special "no new information" version of the consolidation mechanism (the latter being based on repeated instances of a certain pattern of external experience). Since the caricature effect depends partly on the experience of initial surprise followed by a situation favoring the intensive use of unshared and unexamined rehearsal and rumination, the conditions for predicting and controlling the caricature effect are at present only partially understood.

6.2.3 Memory Access Interference

Memories for very similar experiences can interfere with one another during memory access, slowing access and making it less reliable and less accurate. (As indicated in the diagram of the modification cycle, such interference can have strong effects on the memory information available for the filtering stage of the next cycle.) The two main interference effects can be termed the intervening similarities effect and the similarities saturation effect.

6.2.3.1 Intervening Similarities Effect

The requirement to access a memory of an earlier event may be either of two types: requirement for recall or requirement for recognition.

- Recall consists of, for example, responding to the question "What

kinds of vehicles were present in the imagery you viewed before lunch yesterday?" That is, recall consists of accessing memory contents for a focus of attention of an earlier experience, based on receiving a name or description of the situation within which that focus of attention was experienced

- Recognition consists of, for example, responding to the question "Is this frame of imagery one of those that you viewed before lunch yesterday?" That is, recognition consists of accessing a memory for an earlier situation within which currently presented specific information was experienced as the focus of attention.

For both recall and recognition, highly similar experiences that have intervened between the original experience and the current requirement for memory access tend to interfere with the accessibility of the original memory material; the *intervening similarities effect* creates interference with memory access for both recall and recognition. Thus an analyst processing many messages of very similar contents from the same domain, under constant conditions and over an extended period of time, is unlikely to be able to recall the specific messages processed during a certain period of time. Also, the analyst may not be able to recognize a specific message presented for reexamination as having ever been processed.

When the intervening similarities type of memory access interference must be circumvented and can be anticipated, recourse to external memory aids is the only currently effective solution.

6.2.3.2 Similarities Saturation Effect

Concentrated repetitions of highly similar experiences cause proliferation of many highly similar memory contents in related areas of memory. The increased difficulty of comparing across and discriminating between many similar memories causes reduced speed and accuracy in the compare/construct processing of each new related experience. It also interferes with rapid and discriminable storage of the similar new experiences in memory.

The similarities saturation effect can be lessened by providing the individual a chance to refocus attention on different memory contents for a period of time, thus allowing the interfering memories to become less vivid and less immediately accessible. When the recovery phase has been accomplished, capacity is again available to learn new discriminations in that area of memory.

The intervening similarities and similarities saturation forms of interference with memory performance are predictable cognitive mechanisms of information processing. They operate to weaken and diffuse the information available from memory by affecting the speed, reliability, and accuracy of access to memory contents. As indicated by the diagram of the modification cycle, such weakening and diffusion can change the pattern of memory contents that will be used as filtering criteria for the next cycle of experience and memory modification.

To summarize: Memory contents substantially determine the individual's automatic responses to, as well as aware experience of, new information. At the same time, the functioning of memory and of perception is not under the direct conscious control of the

individual. Nevertheless, three potentially predictable and controllable cognitive mechanisms operate in a cycle to modify information contents available from memory. Since memory contents provide a large portion of the information used in making many intelligence analysis interpretations and estimates, the information contents modification cycle is an important concept for suggesting ways to improve intelligence analysis.

As part of this cycle information is filtered, consolidated and otherwise modified. Selective filtering may operate to ignore (filter out) aspects of information that are disparate from stored information. Polarization, stemming from expectations that have been established, may increase the chance of processing information that would otherwise have been filtered, but it may also lead to filtering of other information not directly related to confirmation or denial of the expectancy. Generalization is an important mechanism which operates during the filtering process.

Information which has passed from the senses through the filtering process is consolidated with preexisting information contents. The consolidation process provides a higher degree of access to information frequently called upon. However, it also may lead to various distortions of the information. Memory access is also affected by the structure of memory (the relationship of various kinds of information in storage). Attempts to recall (remember) information frequently encounter interference resulting from unavoidable confusion with similar information. It should be noted that these effects may be due to distortion during the initial storage process (the information was never stored as a discriminable item) or during the retrieval process.

6.3 Structure of Cognitive Capacities

The structure of basic cognitive capacities consists of information storage and routing facilities and their relationships, while the elemental processing dynamics consist of mechanisms for transforming information as it flows through the basic structure. From left to right, the column headings of Figure 6-3 depict the main components of the cognitive structure and their relationship to the analyst environment (the extended work setting):

1. Analytic Work Setting, including External Memory
2. Analyst's Senses
3. Analyst's Sensory Buffer
4. Analyst's Processor Structures
5. Analyst's Internal Memory

Each is described briefly below.

6.3.1 Analytic Work Setting and External Memory

Column 1 of the diagram in Figure 6-3 depicts the work setting, which contains many information channels of the kinds shown in Figure 4-1. Information may be available through media such as face-to-face or telephone conversations, printed materials, computer-based displays, etc.

6.3.2 Senses

Various senses (vision, hearing, touch,) in column 2 are the means by which all information from the environment enters the cognition of the analyst. Each sense type can be distinguished by its receptor organ, the type of experiance produced by the sense, the type of

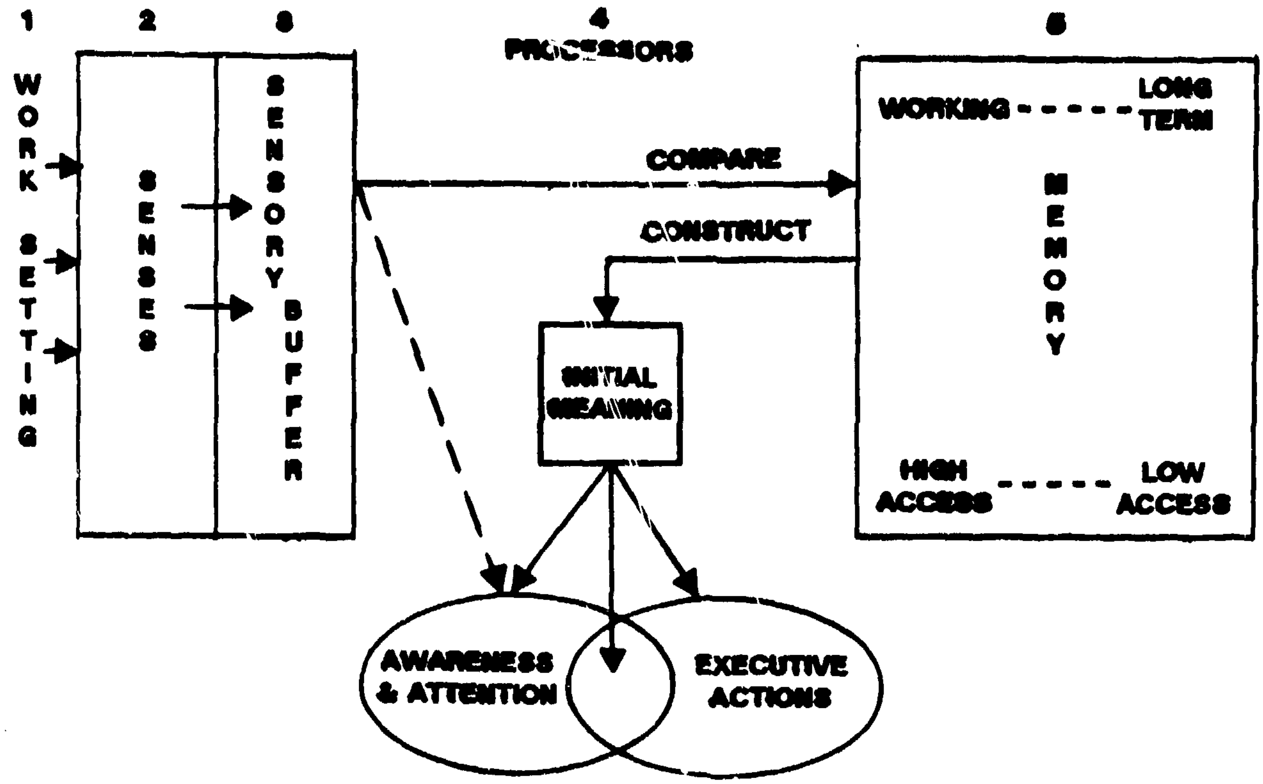

Figure 6-3. Cognitive Structures and Information Flows

physical energy to which the sense organ responds, and the information-carrying capacity of the sense.

6.3.3 Sensory Buffer

This capability (depicted in column 3) accepts raw information from the senses and makes it available to the rest of the cognitive structure, while at the same time preserving the information for a short time after cessation or change in the sensory input. The buffer has several characteristics:

- It *operates like a "push-through" store:* New information from the senses replaces or forces out older information after a certain (small) accumulation in the buffer has been reached.
- There is *partial parallel storage for different senses:* Traces for very recent auditory, touch, or muscular sense inputs outside awareness and attention can be recaptured by shifting the current focus of attention from, for example, the visual to the auditory. (The reader may be able to recapture unnoticed recent sounds.)
- Storage life *is very limited:* From one-half to two or three seconds

is typical.

- It may be *"commandeered"*: Large changes in stimulus intensity for one type of stimulus can "swamp" the buffer capacity and momentarily eliminate the traces of other types of stimuli from the buffer.

- Buffer contents *are OUTSIDE awareness*: Buffer contents normally enter awareness only after they have been compared/constructed with contents from memory (i.e., are made meaningful) and often not even then. Thus, the focusing of attention (the choice of which sensory channel and material to attend to), is often accomplished outside of awareness. That is, the focusing of awareness and attention is accomplished both by processes within and processes outside of awareness.

6.3.4 The Processor Structures

Column 4 of Figure 6-3 contains COMPARE/CONSTRUCT processes which operate to transform the information flowing from the sensory buffer to the memory, and to route it back to the processors. Three processor structures are shown. The

1. *Awareness and Attention Processor* generates awareness and attention for information that flows through it. Conversely, all information flowing outside this processor is outside the individual's awareness and attention, and thus is processed by the:

2. *Outside Awareness Processor* which has a larger capacity than the awareness and attention processor.

3. *Executive Actions Processor* supports the production of external behavior.

These three processors combine their functions to produce:

1. External behavior within individual's awareness.

2. External behavior outside individual's awareness.

3. Internal, unobservable behavior within individual's awareness.

4. Internal, unobservable behavior outside individual's awareness.

6.3.5 Memory

Column 5 represents the overall characteristics of human memory as it is usually understood. It is critical to an understanding of human memory and of cognitive processes to realize that memory and thought are highly structured. Without categories and concepts, an individual would be unable to deal with incoming and stored data. A major aspect of the cognitive model, then, is the structure of memory.

- There is a high degree of correspondence between the categories of information available in the work setting and the categories of information in memory.

- For each category of analytic-relevant information contained in storage memory, there is also corresponding memory information indicating the availability (or lack of) supplementary information of the same category in the work setting.

- The accessibility of contents of memory varies with respect to speed of access, reliability of

access, and level of detail of information available. The overall dimension of accessibility is depicted in the diagram by the scale shown at the bottom of column 5. Highly accessible contents are depicted as "closer" to the processor structures that will use them.

- Memory contents vary with respect to the amount of time they have been in storage. Although storage times are on a continuum, memory researchers have found it convenient to designate recently stored and/or recently accessed and re-stored contents as being in "working" or medium-term memory. Contents with long storage lives and less recent accesses and re-storage are designated as in "long term" memory.

- The amount of information potentially available from long term memory is much greater than in working memory. On the other hand, as indicated by the accessibility scale in the diagram, the information in working memory is more accessible than that in long term memory.

The *storage structure* of memory is uniform across its working and long term portions and across all categories of contents. The structure is built up from "chunks" of experience that are fitted into the "slots" of memory "frame" structures, as follows:

- An experience is organized as an *instance of a type* of something, occurring within an *instance of a type* of background setting (i.e., organized as instances of "figure" and "ground"); for example, a truck figure in a camouflaged position background or a division figure in field maneuvers background. The figure and the ground can be thought of as two gross "chunks" into which the experience is divided. Figure and ground chunks are often further divided and expanded into chunks at greater levels of detail (analogous to the effect of a zoom lens in the visual realm).

- The storage structures of memory consist of frames, each composed of a pattern of slots connected by links. Each slot represents a certain category of experience chunks already stored in memory and is organized hierarchically by increasing level of detail of the experience chunks stored in it. The examples in Figure 6-4 provide phrases describing information category chunks stored in memory frame slots, with progressively more detailed chunks at lower levels in the lists.

- A link in a memory frame is a special kind of slot that represents a certain type of relationship. For example, possible relationships linking two slots designated A and B would be:

  A: is part of B; succeeds B; occurs with B; implies B; is a subclass of B; is a functional equivalent of B; is synonymous with B; implies NOT B; was acquired with B; is associated with B; A and B are: parts of C; subclasses of C; etc.

VISION	HEARING
Vehicle	Moving vehicle sounds
Tracked vehicle	Tracked vehicle sounds
Light tank	Particular motor sounds
Topside	Particular track sounds
Turret	Combined Tank sounds
Turret hatch	Sounds of Specific Tank

Figure 6-4. Example: Hierarchies of Information Storage Chunks

Thus, both slots and links are categories of experience chunks already stored in memory, the categories each having a tolerance limit for accommodating similar new chunks of experience. Each new experience is represented as an "instance" of the category, with content variations appropriately appended.

- The contents of memory are outside awareness until they are accessed by the awareness and attention processor. Ordinarily, when being accessed by the awareness and attention processor, the chunks at various levels of detail in a memory slot are "opaque" to one another; i.e., two different levels of detail from memory do not occupy awareness simultaneously.

Figure 6-5 diagrams an example of a memory frame. Each of the two-way arrows represents a link between a pair of figure-in-ground slots. While all possible relationships between slots have been depicted in the diagram example, many potential relationships between slots in actual memory frames may be non-existent. The contents of slots in the example were selected somewhat arbitrarily from a larger set of possibilities, to help shed light on the concept of a memory frame, as follows:

Time locale slot: stores a time trace organized in terms of "before and after" relationships between chronological anchoring points for significant events, and being more fine-grained for recent experience.

Sensory slot: Often contains vague, general chunks for sensory experiences of vision, hearing, touch, taste, etc.; this is especially true in cases of more abstract experiences involving

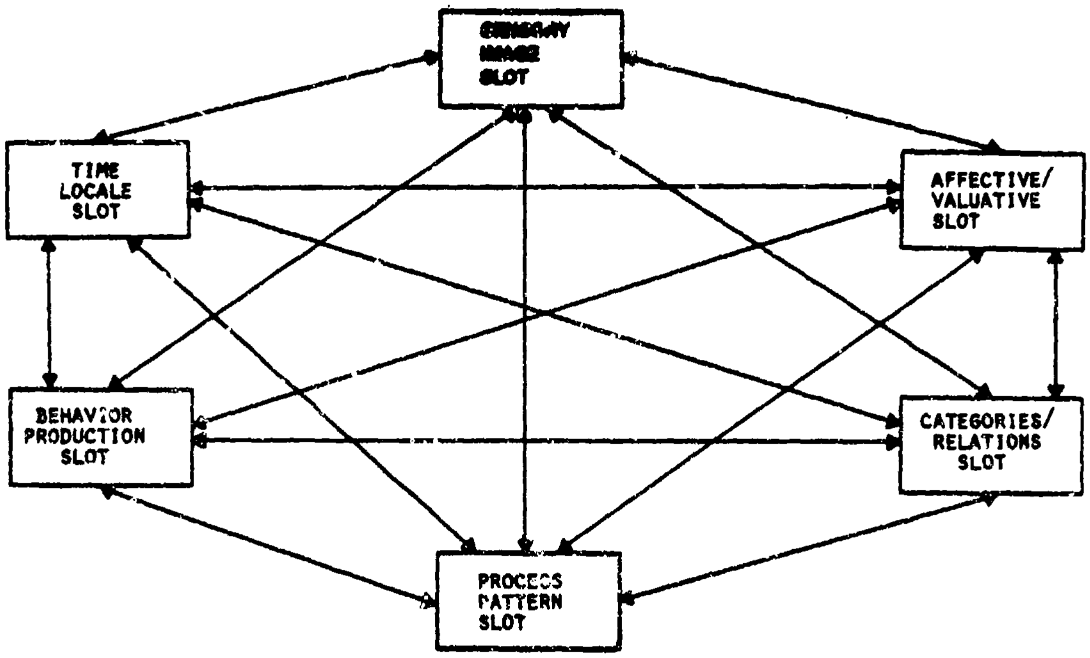

Figure 6-5. Example of Memory Frame Structure

information communicated via language or other symbols. On the other hand, the memory of, for example, a personally experienced motorcycle accident may include vivid sensory chunks in that memory storage slot.

Valuative/affective slot: Contains chunks representing value connotations such as goodness or badness, strength or weakness, and dynamic or static, as well as emotions such as affection, anger, or fear.

Linguistic categories/relations slot: Contains chunks representing linguistic/semantic descriptive categories and relations. Experiences originally conveyed via language and other symbols, and experiences that the individual has talked or written about, are more likely to have vivid material readily accessible in this slot.

Process pattern slot: Contains chunks representing "process phenomena" in which the particular linked instance of experience is understood as one step or stage of a larger, time-distributed

process not directly experienced in the situation. The chunks in process pattern slots are a main source of expectations.

Behavior production slot: often contains little or no material. In instances where a type of experience demands external behavior, a chunk residing in this slot provides the outlines of "plans" for producing the required behavior.

Memory frames are the basic building blocks for higher-order storage structures of memory:

- A frame may operate as a slot in another frame.
- Superframes (systems of frames) develop, which systematize the storage of experience in terms of consistencies based on similarities between frames as well as other types of relationships between them.

To summarize: Raw information from the sense organs flows through the sensory buffer where it is retained only long enough to be accepted by the COMPARE/CONSTRUCT processes, initial phases of which operate outside awareness. These processes rapidly and automatically COMPARE the information input with patterns of information already stored in memory, and CONSTRUCT a meaning (a response) from a combination of the input and memory information. The initial construction of meaning takes place outside awareness within tenths of a second. The meaning may then be used to elicit actions, it may obtrude into awareness and drive thought processes, it may remain outside awareness and result in automatic adjustive reactions, or any combination of these.

Memory may be conveniently divided into a "working" memory, which stores current information for short durations, and "long-term" memory. Information in both parts of memory is stored in patterns called frames, which consist of slots, nodes, or chunks connected by links. The information in slots is arranged hierarchically by level of detail and specificity. The information in links represents types of relationships that hold between the information contained in the slots. A frame may comprise a slot in a larger, more incorporative frame, thus allowing for very complex memory structures to be developed.

6.4 Elemental Dynamic Processes

A brain trace representing an experience chunk exists in the form of a neural code; colors and sounds themselves do not exist in the brain but are represented there neurochemically. When stored in memory, the information represented by such a code is dormant. When a trace representing a chunk in memory is activated and the information represented by the trace is used in processing, the action is referred to as **decoding** the memory trace. Conversely, when an instance of an experience chunk is stored in memory in the form of inactive brain traces the action is referred to as **encoding** the experience. **Matching** is comparing trace codes for similarity. A **match** is an identified similarity between codes.

The basic compare/construct process described earlier (see Figure 6-3) is made up of more elemental dynamic processes consisting of a behavioral sequence of matching, decoding, matching, and encoding steps (MDME for Match Decode Match Encode). The MDME processes operate on the information flowing from the sensory buffer

to the memory and back to the processor structures. In brief, in the MDME sequence, sensory information in the form of neural impulses is:

1. matched grossly against memory information. The memory information activated as grossly similar is then
2. decoded to a depth sufficient to ensure the degree of secondary match necessary in the particular situation. This compare/construct process produces a new configuring or "chunking" of information, which is
3. encoded in the form of new passive brain traces.
4. The newly constructed chunk of information also flows to other parts of the cognitive structure in the form of a Decoded Memory Return (DMR). The DMR may flow to the awareness and attention processor where it may program external behavior within awareness and/or match and decode other memory contents, including awareness of "no significant change." The awareness processor has a limited information processing capacity, and can focus close attention on only one level of detail of an experience at a time.
5. In thought and problem solving, the DMR often originates in cognitive activities stimulated by memory contents rather than by information from the sensory buffer.
6. The DMR may also flow to the executive actions processor, where it operates, in coordination with other behavioral plans information from memory, to program patterns of external behavior. The executive actions processor may operate in conjunction with the awareness and attention processor to produce aware, deliberate forms of external behavior. More commonly, however, the executive actions processor operates outside awareness to produce automatic external behavior in response to DMRs.
7. Under special conditions, raw information from the sensory buffer may momentarily force its way into awareness before being processed through memory by the MDME processes. As a result, there is momentarily no DMR, and the raw sensory information is therefore experienced as meaningless.

To summarize the MDME processes; Several points for application to discussions in the chapter following can be drawn:

- The awareness/attention processor has a limited capacity compared to MDME processes operating outside awareness.
- All information in normal awareness has been filtered and filled in from memory contents by processes usually outside awareness.
- Sensory data from the external world has no meaning unless filtered and filled in from memory contents by processes operating initially outside the individual's awareness.
- Factors that form and control sensory perceptions and attention are mostly outside the individual's control. This is also true of remembering and thinking; individuals cannot force their thought to contain exactly the desired contents.

To summarize the cognitive model: Memory contents substantially determine the individual's automatic responses to, as well as aware experience of, new information. At the same time, the functioning of memory and of perception is not under the direct conscious control of the individual. Nevertheless, three potentially predictable and controllable cognitive mechanisms operate in a cycle to modify information contents available from memory. Since memory contents provide a large portion of the information used in making many intelligence analysis interpretations and estimates, the information contents modification cycle is an important concept for suggesting ways to improve intelligence analysis.

Memory contents are stored hierarchically by level of detail, with gross features and outlines of information at shallower, more accessible levels of storage, and fine details at deeper levels. A central compare/construct mechanism matches incoming raw sensory inputs to similar memory contents and actively constructs a composite return which drives behavior and experience. The compare/construct mechanism also matches inputs from one part of memory with those from another, thus allowing thought and problem solving without external stimuli. The basic memory storage frame structure composed of slots and links allows for very flexible, complex storage structures comprising super-frames and memory systems. The strategies and judgmental criteria used by the action executive processor and the awareness and attention processor are themselves composed of contents from complex memory structures.

7. THE COGNITIVE MODEL IN THE ANALYTIC WORK SETTING

This section reviews the results of surveying the analytic work settings in the light of the cognitive model just presented.

7.1 Special Importance of Memory

A main theme of the cognitive model is that, in normal psychological functioning in everyday environments with "ideal" outside information, the balance of information used from memory and received from the outside favors memory much more than casual observation would lead one to suspect. In many kinds of intelligence analysis, this balance is tipped even further toward use of memory by the conditions of these environments; analysts rarely have what they would view as ideal data coverage of the objects of their interpretations.

Often information from memory provides the sole basis for hypothesizing relationships among data available for interpretation and for classifying various data as relevant, redundant, present, absent, or crucial for the interpretive task. Highly confident classifications of data value can be made only in hindsight, since it is the unique nature of the object or event interpreted that finally determines such classifications. Information models, (models couched in information descriptive terms, and derived from the more general conceptual models defined earlier) provide some aids for classifying available data prior to actual interpretation, but at best serve merely as guidelines, and sometimes even misguide analysis. The analyst is left with the on-the-spot task of dynamically classifying much of the data presented for interpretation.

7.2 Awareness of Memory Function

Often we are not aware that information we are using is coming from memory. Memory information used at even high levels of awareness does not necessarily obtrude into awareness labeled as "information from memory." Figure 7-1 provides a simple illustration of this phenomenon in an example of contributions of memory to the task of identifying a military vehicle masked by a tree. Visible parts of the vehicle provide the cues for matching and decoding memory contents and reconstructing the visually missing parts of the vehicle. As the fill-in is accomplished, the image of the tree is effectively dimmed or even erased from consideration. At this point the tree is down-graded or eliminated from awareness, and a "camouflaged tank retriever" is confidently reported. The fact of using information from memory for fill-in is usually dismissed or not even noticed. The same sequence of data occlusion, fill-in, and dispensing with the fact of occlusion and fill-in occurs continuously for conceptually more complex and subtle forms of experience associated with analysis.

7.3 Memory Aids and Memory Load

The information resources and variables in analytic work settings are usually quite complex (see Figure 4-1). The loads imposed on internal memory are lessened by external memory aids such as maps, reference materials, and computer displays. Such external aids have advantages. The externalized information models they contain (templates, doctrine, IPB, etc.) usually suffer less from memory modification and judgmental distortion factors than models stored in the analyst's cognitive memory. Currently, however, such materials are costly to produce,

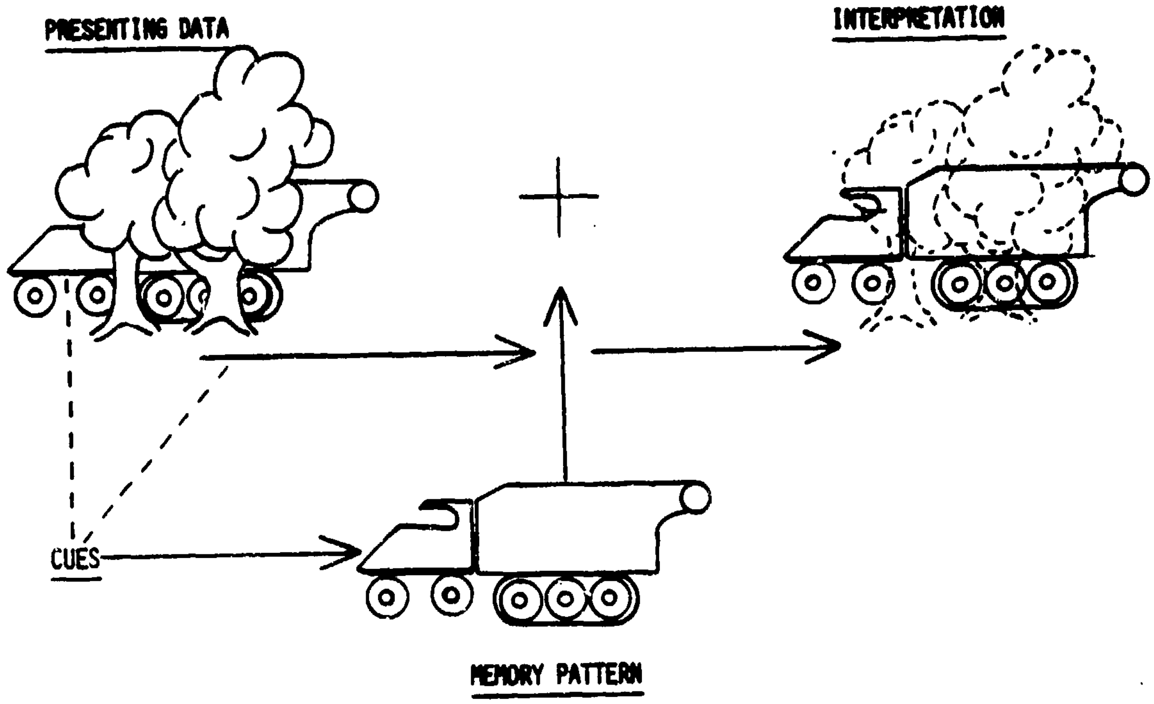

Figure 7-1. Example of Occlusion and Fill-in

slow to update compared with the analyst's internal storage memory, and usually provide only a partial match with the realities toward which they are aimed.

Apart from the potential analytic value of memory-aid materials, their proper handling and use can pose memory problems for the analyst. Passive versions of such supports, which must be remembered and searched out to be of use, can tax an analyst's memory in locating materials. Active versions of such supports (such as alarms, forced displays, flashing prompts, rigid reminder schedules, etc.) create interruptions, distractions, and procedural overload, by diverting the analyst's limited-capacity awareness and attention processor. This is more likely when it is being used for deep processing of extensive stored intermediate results (problem-solving thought).

7.4 Decision Pressure

Analysts must use part of their memory and processing capacity resources to plan and manage their own work behavior. Knowledge about work planning and management is also part of the analyst's internal memory resources,

which imposes memory load when used. The analyst must use available resources of time and information wisely to obtain the best interpretations and estimates possible under given circumstances. No static formula is available for planning the proper use of resources in each new situation; many considerations for intelligence analysis are unique to each situation, and decision making about related cognitive information processing activities must accordingly be dynamic.

Most centrally, the analyst must repeatedly decide when the point has been reached where the results of each analytic endeavor are sufficiently clear to warrant no further expenditure of analytic resources under the current conditions of resource availability. Situational variables that focus pressure on such decisions include:

- Amount of ambiguity and uncertainty in the data and in memory.
- Possible losses or penalties associated with a serious error of interpretation.
- Amount of error reduction possible if more data and analytic resources could be applied to the interpretation.
- Limitations on applying more analytic resources, including time, to the interpretation.

Analytic situations involving great ambiguity, large possible penalties from error, great potential for error reduction with more processing, but severe limits on more processing can cause great decision pressure. Under such circumstances, typical decision behaviors include:

- Fixation on isolated aspects of the situation rather than a *balanced* attention to all parts.
- Excessive oscillation in choosing a final interpretation.
- Lowered predictability and orderliness in final interpretive choices ("leaps" rather than logical steps).

Certain arrangements an procedures observed in analytic work settings can function to forestall decision pressure, to insulate the analyst from it, or to constrain behavior under pressure. These include:

- Step by step task guidelines for data-handling.
- Checklists and templates to help channel thinking.
- Allocation of resources and tasking instructions provided by management.
- Discussion and exercises concerned with:
  - The recognition of decision pressures in a situation.
  - The techniques for redistributing analytic load, if that can help.
  - The uses of accountability procedures as checks.
  - The uses of consulting and consensus among colleagues.

Of course, each of the items listed above also serves other purposes besides lessening the effects of decision pressure. Decision pressure as a phenomenon is recognized with different degrees of explicitness in different work settings, but the problem of lessening the pressure is rarely approached on an explicit systematic basis.

7.5 Memory Resource Management

Concerns of management and analytic personnel about the management of memory resources are reflected in many field activities:

- Controlling analyst's expectations about the most likely meanings of forthcoming data.
- Assigning analysts limited needs to know that are not related to security requirements.
- Planning and maintaining coverage and backup for team members' current knowledge and skills.
- Planning and maintaining feedback on accuracy of analytic performances.
- Improving the quality and availability of external memory supports and aids.

Although the importance and impact of the reliability and quality of memory functions (versus the reliability and quality of data) is occasionally remarked, the magnitude of this importance as shown by the cognitive model is usually less clearly grasped.

7.6 Team Memory

An external memory resource widely used by analysts--especially under trying circumstances--is the "team memory" represented by colleagues. Colleagues have advantages as external memory supports because:

- query formulation is comparatively easy; a colleague can not only provide information, but can help the analyst define a need and frame a query in terms understandable to the colleague.
- rapid response is available; a colleague can quickly indicate whether or not any help can be expected. This allows the analyst to search widely in a short time if necessary.
- rapid update of colleagues' memory contents can be achieved under some conditions for which materials-based memory support systems may require considerably more time for update.
- self correction of external memory resources is somewhat automatic since colleagues tend to recognize their memory shortcomings and try to correct them. Materials-based memory support systems could, in principle, be designed this way, but such systems are not likely to be realized in the near future.
- active problem solving by colleagues is frequently included as part of the team-memory services to one another; relevant memory contents are not only located and communicated, but also compared, placed in contexts, evaluated, and conclusions are drawn.

Colleagues can be disadvantageous as external memory supports because:

- disruption of colleague tasks is often an inescapable result of using team-distributed memory. The availability of team-distributed memory cannot be guaranteed under conditions of high organizational work load, unless extra personnel have been planned for such functions.

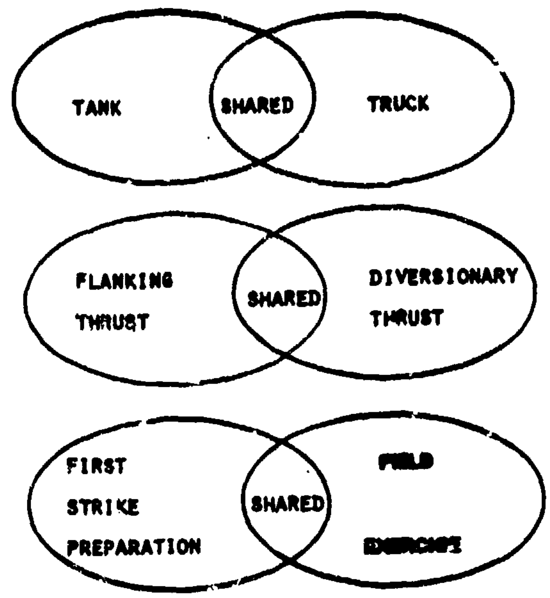

Figure 7-2. Examples of Shared (Equivocal) Data Patterns

7.6.1 Disparity Analysis A necessary part of the team memory approach is the analysis of disparities between interpretations supplied by individuals with different backgrounds and viewpoints. Objective "ground truth" about real world situations (as distinct from exercise or laboratory situations) is rarely available, even historically, and never during the actual task of interpretation. Therefore the analysis of disparities between different interpretations remains a fundamental technique for evaluating interpretations. Although comparisons among different interpretations is usually the *only* means available for checking the soundness of interpretations, disparities among different individuals' interpretations of the same data result from differences in memory contents.

The presence of equivocal data is most often the condition that prompts different individuals to produce disparate interpretations. This point is illustrated by Figure 7-2. The top two ovals in the figure show that a tank and a heavy truck have certain shared attributes (at the visual, auditory, and ground sensor levels). If only these shared attributes are available in the data to be interpreted, the data are equivocal

regarding tanks and trucks. In that case, either interpretation can be made, and the interpretation produced will be controlled by the analyst's current pattern of accessible memory contents. The figure also depicts the same phenomenon applying to information about larger, more complex realities.

7.7 System Aggregation Models for Data and Concepts

Related to the team functioning concept, but distributed over a wider system domain, are the continuing change-induced tasks of reapportioning functions for aggregating data and concepts at various points in the system. Data selection, aggregation, and conceptualization practices within an analytic work setting are developed on the basis of current factors such as technical skills, levels of correlation and fusion functions, standing uses for the interpretive products (targeting, ENSIT, IPB, planning, operations, etc.), and special, client-targeted, information packaging requirements. These arrangements develop out of the necessity of the division of work within the system and reflect experience with requirements, conditions, and capabilities at various places in the organizational network.

The resulting patterns of memory usage and modification in each type of work setting create systems of memory frames (superframes) that constitute a typical "view of the world" from the vantage point of that setting. Indications of such different views appear in answers to such questions as: How do you perceive most data (eyes, ears, etc.)? What kinds of mental images do you use in your work? How many different pieces of information must you typically bring together to make your interpretation? Typically, how many alternative interpretations for the data will you entertain mentally? How large a geographical area will typically be occupied by a phenomenon to be interpreted by you? What is an average span of time over which an interpretation made by you can be expected to remain in correspondence with the real-world objects or events? Such specialized viewpoints are an integral part of the efficient performance of analytical work in the various settings.

The necessarily different work-oriented world views of different settings can create interferences in information passing between settings and can compound problems of analyzing the disparities between interpretations from different settings. One manifestation of this is the desire, at lower levels of the system, to see the big picture and, at higher levels, to evaluate the raw data. Information models in higher-level analyst's memories (sometimes made explicit in material form) occasionally contain references to different viewpoints experienced in different work settings. Nevertheless, there are as yet many unexplored relationships between arrangements for aggregating data and concepts, and the use of explicit information models.

8. IMPLICATIONS OF FINDINGS

No claim is made that all of the implications of this study's findings have been noted. None of the implications found have been evaluated in the present project, since such evaluation should be premised on the successful validation of the cognitive model of analytic activities. Implications that suggested themselves to the project team are presented primarily as questions for which answers might be found either within existing organizational expertise or by new investigations. Some possible implications for a number of areas of management concern are discussed in the following paragraphs:

8.1 Analytic Accuracy

The strongest implication of the study findings is judged to be the possible leverages for improving analytic accuracy that might be gained by studying memory modification cycles in the individual and team contexts of analytic work settings. The fundamental goal toward which all efforts at improving intelligence analysis are finally aimed is improving the accuracy and quality of interpretive products. Improvements can result from factors such as progress in management philosophies and techniques, advanced systems for support of analyst's memory requirements and for complex judgmental tasks, improved arrangements for performance feedback, more accurately directed training, improved selection and career management, and better data to interpret. Underlying all such improvements will still be the indispensable high-grade performance of the analyst's memory, and governing the performance of the analyst's memory will be the memory modification cycle depicted in the model.

It should be possible to determine to what extent efforts to develop aids to memory suggested by the model, such as examining expectations, performing deeper processing, sharing rehearsal experiences, reviewing earlier records, and refocusing attention under load can be helpful in improving the memory performances of analysts. If such aids are found helpful, what are the implications for training the managers of analytic teams, for designing memory support aids for analysts, for providing performance feedback arrangements, and for training analysts? Can interpretive bias factors be predicted in practical situations?

8.2 Management of Analytic Work

Next to the effective performance of the analyst's memory, the most critical element for improved analytic performance appears to be insightful and effective management for analysts. Many studies in the organizational and management fields indicate that the beneficial effects from technical support improvements, improved feedback, training, and selection can be counteracted by some management orientations. Conversely, management that is insightful about factors affecting specialized organizational and individual performance may extemporize many desirable arrangements and procedures.

Assuming that various parts of the findings of this study are validated, how important is having knowledge of the findings for managers of different types of analytic work? What management approaches and practices for various circumstances are implied by the model? Of particular interest are memory management techniques, factors in using team memory, and safeguards against decision pressure.

8.3 System Supports for Analytic Functions

Much is already known about the usefulness of various system supports for analytic work, and it is clear that modern intelligence systems cannot hope to perform all the functions required of them without carefully planned and designed automated supports. The general problems of providing non-obtrusive but active memory and judgmental supports for analysts were alluded to earlier. The recent history of developmental research efforts for automated analytic aids includes continuing efforts to provide not only conventional automated support for data and message files, but semi-automatic message handling and other automation aimed at forming and maintaining system-based versions of the conceptual models (and implied information models) used by analysts. A number of questions regarding such supports are prompted by the present study findings.

Static versions of many conceptual and information models currently exist in documented form (e.g., Order of Battle, Intelligence Preparation of the Battlefield). How will dynamically supported versions of such externalized models affect the expectations of analysts? In what ways might the models serve as armatures for team analyses of interpretive disparities in problematic situations? In such uses, under what conditions will they: cause interference; clarify analytic alternatives; support or curtail productive hypothesis generation; focus premature convergence on inaccurate interpretations; speed correct interpretations; accelerate recognition of anticipated events; delay recognition of marginally unusual events; serve as high-capacity formats for transmitting accurate information; serve as high-capacity formats for transmitting somewhat inaccurate information?

Such questions become even more significant in light of the fact that there presently exist concepts and working models for various advanced, experimental, computer-based facilities for conducting team judgment processes via networks of CRT terminals. Team communications can be constrained to any desired pattern through such facilities, and computer information stores and graphic capabilities can combine to allow members to form and display their individual hypotheses to one another in vivid ways and to overlay their various offerings to facilitate comparisons.

8.4 Performance Feedback Arrangements

Is there something to be learned from discarded interpretations? Post hoc analyses of intelligence lapses that reach public awareness sometimes include corollary "I told you so" material. There is no presently feasible way to save discarded alternative interpretations on a large scale, but it seems likely that these interpretations would sometimes have proven more accurate than the ones chosen for use. Only large-scale inaccuracies on important events are likely to prompt post hoc inquiries, with the result that potentially superior but unused everyday analytic performances go unnoticed.

Yet, the cognitive model suggests that more can be gained by focusing on comparative degrees of success than upon scattered instances of highly noticeable failure. Deep cognitive-processing rehearsals of analytic failures will instill highly accessible memory contents about what not to do, which can be

very important. Nevertheless, such inhibitory contents suggest the proper ways to proceed only on a default basis (by exclusion). A rapid and effective response is more likely to be generated by accessing memory materials related to comparative successes.

Can the analyst profit equally from negative and positive memory exemplars that "fit" a certain situation? It is worth recalling that the cognitive model indicates that the individual is not free to choose what will be recalled in a given situation: memory access functions are mostly automatic and outside of awareness. What will emerge first from memory is what has been processed most frequently and deeply. Since there are many more ways to do a thing wrong than to do it right, there is ample opportunity to load memory with detour signs rather than positive directional pointers.

Regarding feedback arrangements from a costs/benefits point of view, part of the massive ADP support anticipated for analytic activities of the future might prove to be used effectively for storing generated alternative interpretations and automatically comparing them with unfolding events.

8.5 Training for Analytic Work

The study findings indicate two main points for training:

1. It is essential to consider the analyst's detailed training requirements from a systematic viewpoint of required memory contents and required memory functioning. In much successful analytic work, a wider range of memory contents are used than superficially "meets the eye."

2. Having once learned something does not necessarily mean that it will be appropriately accessible from memory when needed. The memory modification cycle of the model shows that a filtering and consolidation buildup period is required, in which earlier learnings are refreshed and configured to be properly accessible by cues from the concrete analytic situation of the present.

   Moreover, success of the buildup process is not fully under aware volitional control of the analyst. The memory modification cycle mechanisms of filtering, consolidation, and interference will operate outside awareness during the buildup period. Efforts must therefore be made to channel the results of these mechanisms in desired directions.

8.6 Selection and career management

The analysts' self-report image profile presented in this report was gleaned mostly from successful experienced analysts and should be given serious consideration as providing some guidance for selection criteria for analysts. This is especially true since some personnel selection studies have shown self-report assessments to have comparatively good validity for some kinds of occupations.

Although the study results provide few clear indications for the more technical aspects of selection procedures, it seems apparent that potential analysts must be selected in terms of demonstrated conceptual abilities, the absolute levels required depending upon the individual's (realistic) future aspirations for advancement to work settings

higher in the analytic continuum. For many modern analytic settings, hard science or technology interests appear very desirable. For others, a stronger social and political science orientation is needed. Except for assumed career termination in the lowest "end-of-the-pipe" source production work settings, demonstrated real success in completing high school and indicated capacity to do at least beginning-level college work is probably essential.

Interest in military science and related issues is not an entry-level requirement, but early clear signs of voluntary growing professional interest in such matters should be a prerequisite for tagging candidates for advancement and rotation to different and higher slots within the analytic continuum.

The successful analyst's orientation toward ambiguity is at present an open issue. Tolerance for ambiguity is essential to the analyst in dealing comfortably with sparse and equivocal data patterns associated with analytic work. On the other hand, a vigorous natural interest in reducing ambiguity also appears important. This aspect of the analyst's management and reworking of internal memory contents appears to be a productive topic for investigations, using the concept of the contents modification cycle presented in this report.

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1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
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1 USASMA, Ft Bliss, ATTN: ATSS—LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA—CTD—ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD—PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
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1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO—E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC—CI
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1 USA Topographic Lab, Ft Belvoir, ATTN: ETL—TD—S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL—GSL
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1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS—CTD—MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI—TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI—TEX—GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI—CTS—OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI—CTD—DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI—CTD—CS
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1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
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1 HQ, TCATA, ATTN: AT CAT-OP-Q, Ft Hood
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1 HQ, USMC, Commandant, ATTN: Code MTMT
1 HQ, USMC, Commandant, ATTN: Code MPI-20-28
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1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaison Ofc, AMC, Alexandria, ATTN: AMCGS–F
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1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV–ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE–T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL–AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST–T–RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST–D–A
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1 HQ, DARCOM, Alexandria, ATTN: CDR
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1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
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1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
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1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
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1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
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2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
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1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL–4), ATTN: DOC SEC
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1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
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5 NavPers & Dev Ctr, San Diego
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1 Nav Electronic Lab, San Diego, ATTN: Res Lab
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1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
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1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
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1 Nat Clearing House for MH–Info, Rockville
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1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
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4 British Def Staff, British Embassy, Washington
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1 Militaerpsykologisk Tjeneste, Copenhagen
1 Military Attache, French Embassy, ATTN: Doc Sec
1 Medecin Chef, C.E.R.P.A.–Arsenal, Toulon/Naval France
1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
1 Ministerie van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands